EW YORK

THE

FOUNDRY TRADE JOURNAL

AND PATTERN-MAKER.

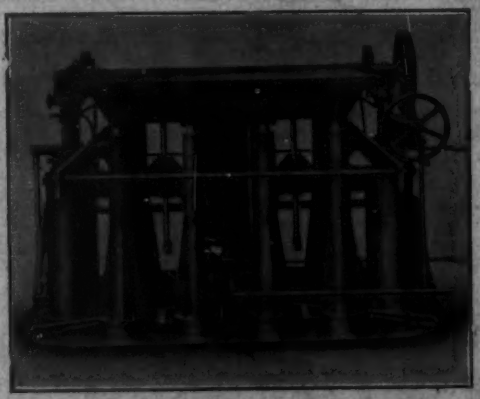
Vol. 21. No. 209. MAY 1919. Price SIXPENCE Net.

JOHN MACDONALD & SON, LTD.

ENGINEERS,

WATT STREET, MARYHILL, GLASGOW.

"AJAX" TURNOVER JARRING MOULDING MACHINE.



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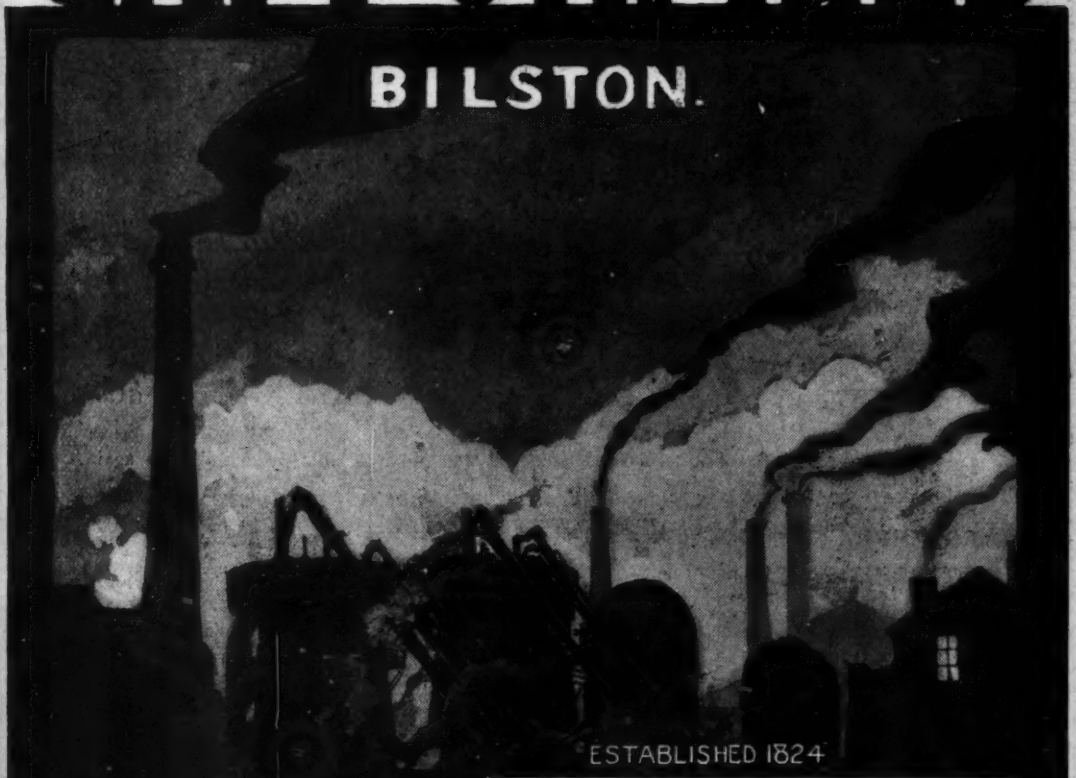

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All Dressings are Sterilized and in Cartons.

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1 „ Large Body Dressings.
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½ „ Sterilized Eye „
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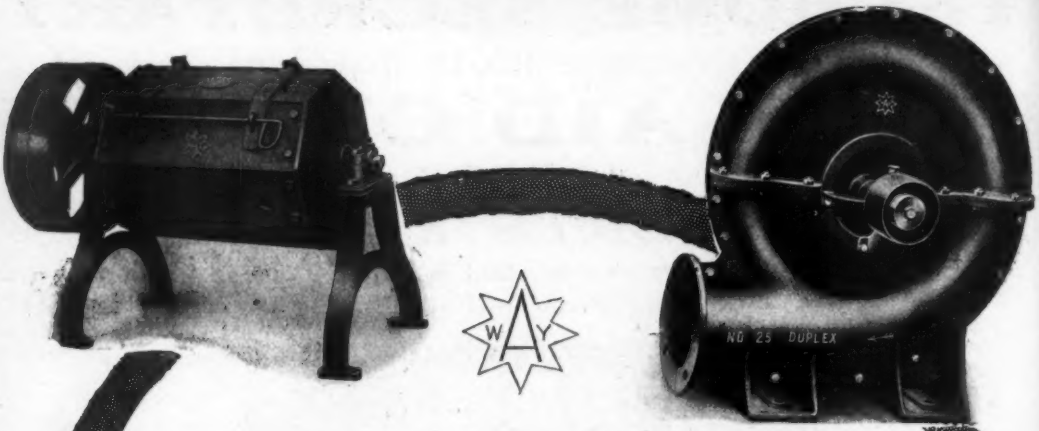

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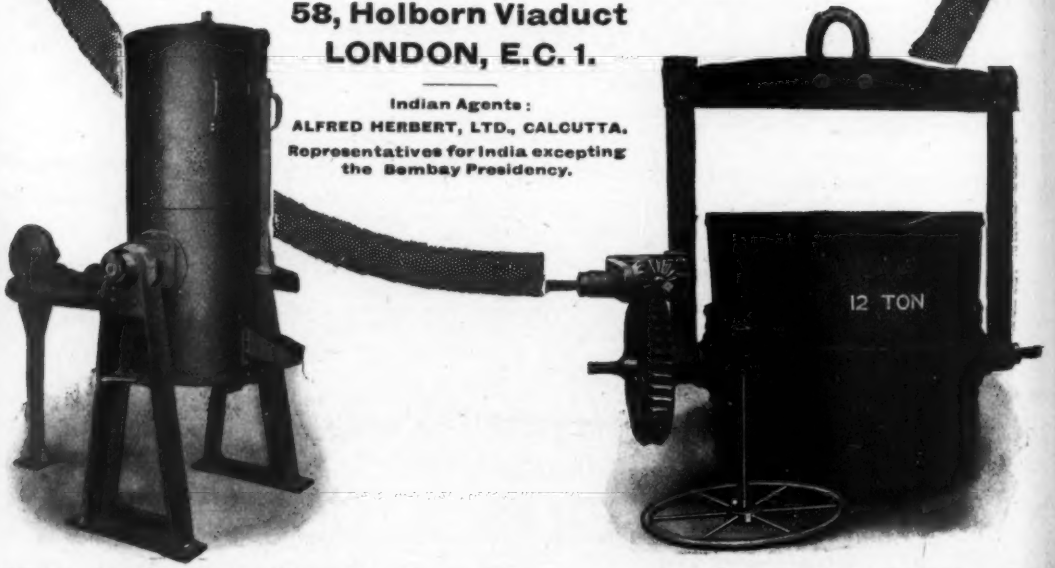

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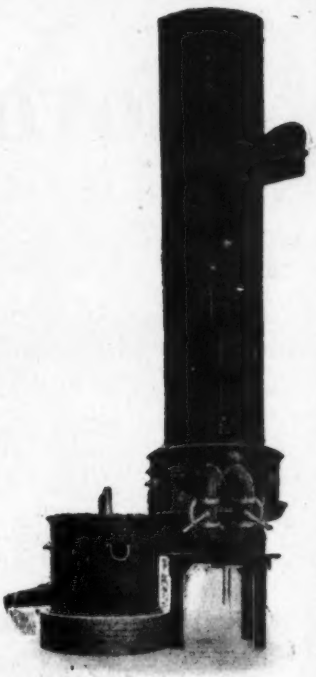

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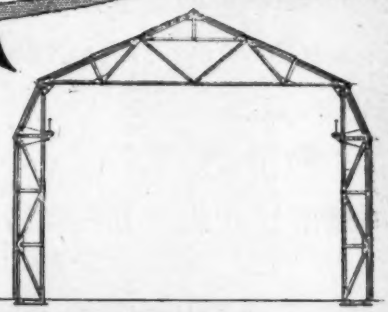

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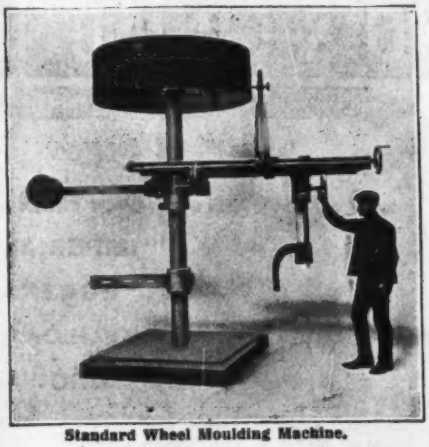

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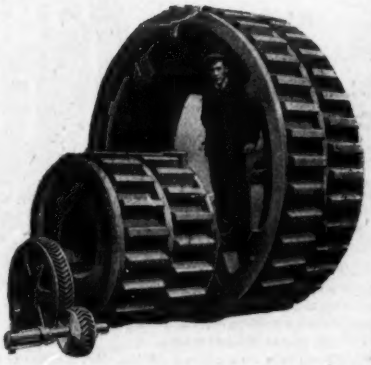

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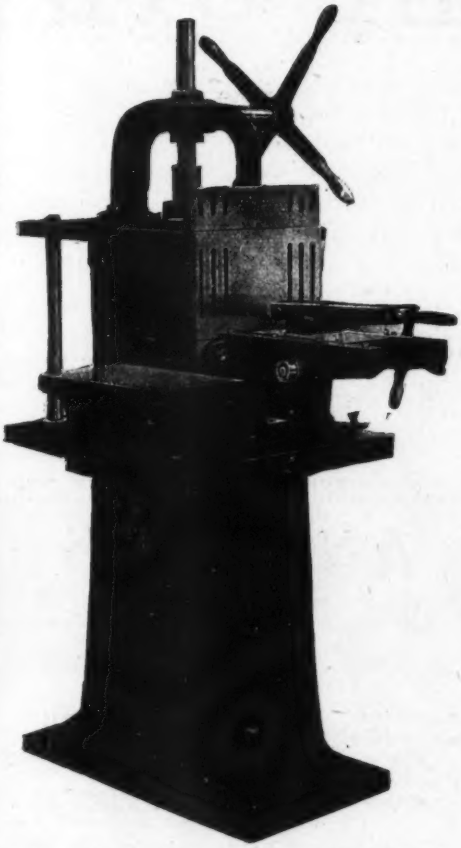

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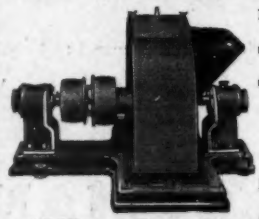

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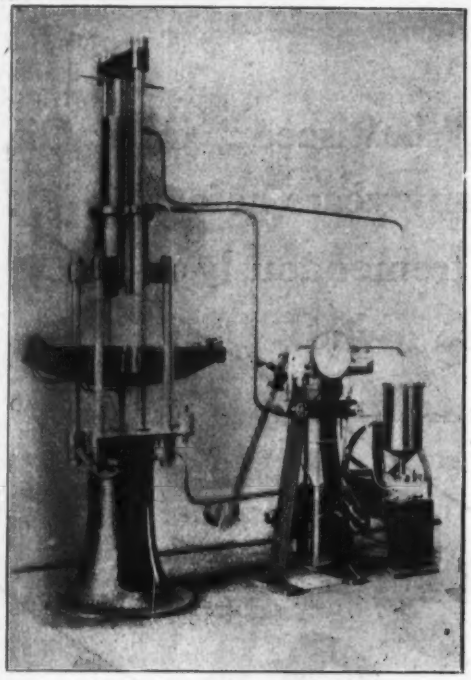

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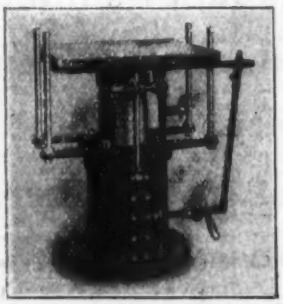

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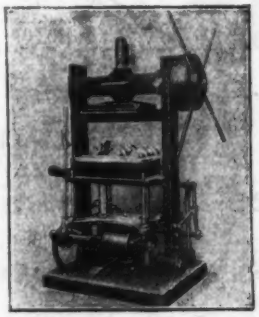

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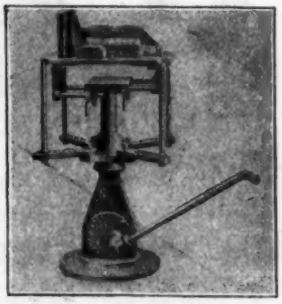

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The Foundry Trade Journal

AND PATTERN MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

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Contents.

	PAGE
Notes and Comments	285
American Pig-Iron Output	286
Making Cast-Steel Anchor Chains	288
The Casting of Alloys	290
Jubilee Meeting of the Iron and Steel Institute	293
Queries	294
The Electric Furnace in the Foundry	296
The Booth-Hall Electric Furnace	301
A New Type of Electric Furnace	302
Large Electric Steel-Melting Furnaces	304
Developments in Electric Iron and Steel Furnaces	311
Gas Standards	323
Correspondence	324
The Foundry from an Engineer's Point of View	326
Wheel Moulding	330
Pattern Turning	331
Visit of American Foundrymen's President	336
British Foundrymen's Association	342
Silica Refractories	345
Trade Talk	346
Vickers-Petters, Limited	349
Parliamentary Notes	349
Applications for Patents	349
Deaths	350
Personal	350
Legal	352
Cold Blast Pig-Iron	352
New Companies	354
Monthly Price List	358
Small Advertisements	359

NOTES AND COMMENTS.

Uncontrolled Pig-Iron.

At the end of last month all Government subsidies to iron and steel manufacturers ceased. The view of the Ministry of Munitions is that in controlling the prices of iron and steel they were mainly looking after the interests of the consumer. Certain is it that without the control and subsidies prices would have long ago reached much higher levels. The effect has been, however, that in the iron and steel trade war profits, so-called, have been on a very modest scale. The grant of a subsidy was made conditional on the production of a cost sheet, and the subsidies granted were only such as would give the maker a moderate profit on his output. It is possible to put very good arguments forward both in favour of and against the subsidy method. In favour there is the unquestioned fact that with constantly changing prices the work of the various Government steel-consuming Departments would have been much more difficult. Now that the subsidies are at an end, and with a view to forming an opinion as to what are likely to be the levels of prices, we have compiled a list of those which have been payable in connection with pig-iron.

The coke subsidies amounted to from 4s. 6d. to 7s. 3d. per ton, this last figure being applicable to the Midland counties. These were only granted in the last few months of the war, to meet the increased cost of coal, amounting to 4s. a ton (June 24 and July 8, 1918), and an increase on July 1 last in the wages paid to coke-oven men. The rates are as follows :—

Coke Subsidies.

	Furnace coke. s. d.	Foundry coke s. d.
Northumberland and Durham ...	5 7	5 7
Midlands (Lancs., Staffs., Yorks., Derby, Lincs.)	7 3	3 6
Scotland—		
By-product	4 6	4 6
Beehive	7 0	7 0
South Wales and Mon.	5 0	5 0
Cumberland	4 9	—

The increase in the cost of foundry pig-iron due to the removal of subsidies will therefore be greatest in the case of the Derbyshire foundry irons. This, on a coke consumption of, say, 30 cwt., will mean about 11s. a ton increase from this source alone The increase in the cost of hematite will of course be less, depending on the coke consumption.

The rates on basic forge or foundry pig-irons have been as follows :—

Basic, Forge and Foundry Pig-Iron Subsidies.

	£ s. d.
North-East Coast	1 2 9
Derby, Leicester, Notts, and Northants	1 0 3
Lincolnshire	0 18 4
South Staffs, Shropshire and Worcestershire, part mine iron	1 10 0
North Staffordshire	1 15 6
Scotland	1 19 6

These subsidies have gradually increased in amount since July, 1916, when the Government refunded to the Scottish makers the increased cost of imported ore. The fact that the Scottish makers use a good deal of imported ore accounts for the high Scottish rate, the total on this account being 17s. per ton. In the case of the other districts the subsidies were first

started in September, 1917, and were then given to cover the increased cost of fuel and wages arising from the Coal Controller's award at that time. They were subsequently increased to meet the 12½ per cent. wages increase on January 1, 1918. There have also been various increases of smaller amounts to meet the increased cost of local ironstone, stores, limestone or wages, as the case may be. As regards hematite, the figures are :—

Hematite Pig-Iron Subsidies.

	£	s.	d.
West Coast	1	2	4
East Coast	1	5	9
Scotland	2	3	9
South Wales	1	10	6

In the case of hematite the subsidies vary, to some extent, with the amount and cost of imported ore used. The proportion falling to this account varies between 26s. 6d. in Scotland, 19s. in South Wales, 18s. 6d. on the East Coast, and 5s. 7d. on the West Coast. In the case of the latter district the subsidy includes the sum of 5s., being the estimated loss on the Government taking over the local iron-ore mines in September, 1917. The remainder of the subsidy is made up from items similar to those enumerated in the case of basic and foundry irons. The subsidy falling to imported ore has been increased from time to time till it has reached the above figure, the increases being due to the increased cost of the ore f.o.b. Spanish ports and to the fall of the £ sterling exchange into pesetas. As regards freight, in addition to the subsidies given above, paid direct to the pig-iron makers, the Government have been paying, until last month, the extra freight on imported ore in excess of the 1915 rate of 17s. Bilbao, which was the freight on which the maximum prices of hematite were fixed, as well as increased charges due to war risk insurance.

These figures give some indication of the increased prices for pig-iron after May 1. In the case of hematite, much depends on the level of sea freights, but if we assume that freights are 21s. Bilbao, this means 8s. a ton on pig made from imported ore. Then there is the subsidy, the increased cost of unsubsidised coke, and the advance in wages due to the eight-hour day, decreased outputs and other causes; it follows that hematite must have added to it 8s. freight + 25s. 9d. subsidy + 8s. coke + 8s. 3d. increased costs, or a total of 50s. a ton, making East Coast pig-iron £8 12s. 6d. a ton, as against £6 2s. 6d. under Control. In like manner Scottish hematite will fall to be increased by £3 5s. or £3 7s. 6d., making the price about £9 5s. to £9 10s. a ton. West Coast hematite may be able to manage with a smaller advance than East Coast, but this depends on the course of freights and the relative cost of Cumberland ore. In the case of basic and foundry irons the increased cost will be variable. The position varies considerably, but, roughly speaking, the increase will be from £2 to £2 10s. a ton.

Iron and Lime in Silica Bricks.

In a Paper recently presented to the French Academy of Sciences by M. M. Bied, tests made by him to ascertain the effect of iron and lime on silica bricks have revealed the remarkable fact that appreciable quantities of iron oxide practically do not lower at all the fusion point of silica ($Si O_2$) bricks, not even in the presence of lime (Ca O). Test pats of 2 in. diameter and 1.15 in. thick were made by compressing various mixtures and then fired at temperatures measured by Seger cones. In a preliminary experiment with a mixture of 75 parts of sand from a certain quarry and 25 parts of roasted pyrites after being fired for an hour at 1,500 deg. C., bulged 4 per cent., but the pats remained perfect. The same mixture agglomerated with a 43-deg. Bé. solution of sodium silicate (waterglass) and fired to the same temperature was completely fused. Assuming the fusion point of the sand (98 per cent. $Si O_2$) to be 1,750 deg. C., this was evidently not lowered more than 10 deg. per 1 per cent. $Fe_2 O_3$. With a view to ascertain whether lime in presence of iron in silica bricks had any deleterious effect, two sets of bricks made of 91 parts of sand from the same quarry and 9 parts of pyrites were tested, in the case of one set 2 per cent. of lime and in the case of the other set 2 per cent. of waterglass having been added to the mixture. Both sets were fired for an hour at 1,500 deg. The first set of bricks bulged 3.8 per cent., but retained its sharp arrises. The second set bulged only 0.8 per cent., but its arrises showed incipient vitrification. A second series of tests was then made with six batches of bricks of the following compositions, and with the following results as regards bulging :—

	I.	II.	III.	IV.	V.	VI.
Quartz	100	100	100	100	100	100
Pyrites	3	3	4	4	5	5
Lime	0	2	0	2	0	4
Bulging at 1,450° ...	3.8	3.0	4.0	2.0	4.0	3.0
Extra do. at 1,700° ...	4.0	2.8	1.8	4.4	1.8	3.0

The fusion point of a mixture composed of 100 parts of quartz, 3 parts of pyrites, and 3 parts of lime, was 1,725 deg. C.; of another mixture, consisting of 100 parts of quartz and 2 parts of lime, without any roast pyrites, was 1,730 deg., the latter temperature being the same as that at which a leading brand (Stella) of German brick began to show signs of fusion. The difference of 5 deg. C. was within the range of experimental error. A brick made from the ferruginous mixture and kept in a crucible steel furnace at 1,600 deg. for several days bulged 1.8 per cent., but remained otherwise perfect.

Annual Meeting of British Foundrymen's Association.

It has been decided to hold the Annual Meeting and Conference of the British Foundrymen's Association this year at Liverpool. The meetings will be held on July 17, 18 and 19 and will include the presentation of various papers of technical interest, visits to works, etc., and social functions will also be a feature of the gathering. A very successful Conference is anticipated, and the new Branch of the Association which is projected for Liverpool should receive considerable stimulus from the function being held in that city.

American Pig-Iron Output, 1918.

The tonnages published in Statistical Bulletin No. 1, of the American Iron and Steel Institute relative to the output of pig-iron in the United States in 1918, classified according to grades, are as under, compared with 1917 :—

	1918. Tons.	1917. Tons.
Basic	18,646,174	17,871,662
Bessemer and low-phosphorus...	13,024,966	13,714,732
Foundry and ferro-silicon ...	5,142,607	5,228,258
Malleable	1,117,914	1,015,579
Forge	393,932	34 ,707
Spiegeleisen	283,853	192 985
Ferro-manganese	333 027	260,125
All other	109,518	92,168
Total	39,051,991	38,621,216

The total output of all grades in 1916, the banner-year, was 39,434,797 tons; with this exception last year's output is the highest on record. The decrease in the output of the first half of 1918 (total 18,227,730 tons, as against 19,250,235 tons in the first half of 1917), was due to the extremely cold weather and snow, which prevailed early in the year. In the second half of last year production was hampered by the prevailing epidemic of influenza.

All grades of pig-iron are included whether made in blast or electric furnaces. Low-phosphorus iron is iron running under 0.04 per cent. in phosphorus. Iron containing more than 0.04 per cent., but not more than 0.10 per cent. of phosphorus, is classified as Bessemer. Iron containing 7 per cent. or over of silicon is a classified as ferro-silicon. Under "all other grades" are included white and mottled iron, direct castings and miscellaneous ferro-alloys.

Making Cast Steel Anchor Chains.*

By C. K. Brooks.

This being an entirely new method of chain making, the first problem which required attention was the working out of suitable foundry methods for producing chain links in sand moulds and uniting them into continuous lengths of chains. A number of quite successful methods were evolved, some of which are shown at Figs. 1 to 14. Connecting up the links was accomplished in either of two ways:—(1) The continuous process in which the entire chain was poured at one heat into previously prepared and united moulds by filling one interlinked mould after another; and (2) the pre-cast link method in which half the links comprising a complete length of chain are cast separately, shaken out, cleaned, and inspected, and made ready for incorporation into the finished chain. Subsequently these links are placed in moulds in the form of cores, and coupled up into continuous chain by pouring in other moulds for similar links interlinked with the pre-cast links. Any of the illustrated methods of making moulds is equally applicable to the continuous process or the pre-cast link process.

Table I.—Static Tension Tests of Chain.

Test No.	Size. In.	Weight of test chain. Lb.	Elongation, ins., after Proof load.	Breaking load.	breaking load plus 40 per cent.	Load at rupture. lbs.	Remarks.
1	1⅛	40	0.03	0.04	0.08	213,600	Broke No. 3 link. Section of metal solid.
2	1⅛	40	0.03	0.04	0.07	198,700	Broke No. 3 link. Section of metal few small blow holes.
3	1⅛	40	0.02	0.04	0 00	180,700	Broke No. 3 link. Section of metal honey-combed.
4	2	123	0.03	0.06	0.13	456,400	Broke No. 4 link. Small shinkage in each fracture.
5	2	122	0.03	0.06	0.09	400,000	Broke No. 3 link. Section shows solid
6	2	122	0.03	0.05	0.10	403,000	Broke No. 4 link. Section shows solid
7	2	225	0.20	0.27	0.45	381,900	Broke top "E" link. Section shows few small blow holes
8	2	223	0.10	0 22	0.63	346,500	Broke bottom "E" link. Section shows few small blow holes
9	2	223	0.07	0.14	Not obtained	316,100	Broke bottom "E" link. Section shows few small blow holes.
10	2⅛	174	0.05	0.09	0.20	494,400	Broke No. 1 link. Section shows solid
11	2⅛	174	0.07	0.13	0.33	495,400	Broke No. 3 link. Section shows solid
12	2⅛	175	0.06	0.11	0.22	513,200	Broke No. 5 link. Section shows solid
13	2⅛	172	0.02	0.05	0.14	502,400	Broke No. 3 link. Fractured through defect
14	2⅛	171	0.03	0.07	0.16	491,000	Broke No. 5 link. No. 3 link defective
15	2	—	0.65	0.65	0.67	452,700	Broke No. 2 link. Section shows solid See also dynamic test No. 4.
16	2⅛	251	0.00	0.00	0.00	764,700	Broke "E" link. Section shows few blow holes in one side
17	2		0.72	0.73	0.74	467,100	Broke No. 3 link. Section shows small shrinkage one side. See also dynamic test No. 8.

Another problem was the character of the mould. Recognising the vital importance of sand castings in a product of this nature, we came to the conclusion quite early in our experiments that all the links should be produced in dry-sand moulds. The methods of application of gates and risers have also required some study, the details of which need hardly be set forth here. Suffice it to say that we have been able to secure excellent results both in pouring through the stud and through the side of the link.

Fig. 15 is a photograph of a tension testing machine, and Tables I. and II. show the resulting tests.

Testing the Chain.—The tests were conducted on a vertical screw-type static testing machine of

Table II.—Dynamic Tension Tests of Chain.

Test No.	Size, in.	Material.	Elongation, in., after 3 blows at— 5 ft.	10 ft.	15 ft.	20 ft.	25 ft.	Total blows at 25 ft.	Total blows at 30 ft.	Total blows at 35 ft.	Chain broke on	Total elongation.
1 (*a*)	2	Wrought	0.02	0.05	0.15	—	—	—	—	—	1st at 20 ft.	0.15
2 (*b*)	2	Wrought	0.00	0.02	—	—	—	—	—	—	2nd at 15 ft.	0.02
3 (*b*)	2	Wrought	0.00	0.02	—	—	—	—	—	—	2nd at 15 ft.	0.02
4 (*c*)	2	Naco	0.01	0.05	0.09	0.13	0.27	50	20	—	None	0.65
5 (*d*)	2	U.S. Navy	0.10	0.34	0.68	1.37	2.21	6	—	—	6th at 25 ft.	—
6 (*e*)	2	U.S. Navy	0.06	0.32	0.74	1.32	2.08	10	2	—	None	3.85
7 (*f*)	2	Naco	0.02	0.02	0.03	0.05	0.10	10	1	—	None	0.72
8 (*g*)	2	Naco	0.08	0.10	0.15	0.19	0.27	10	10	10	1st at 30 ft.	0.24

(*a*) Broke Nos. 4 and 5 links. (*b*) Broke No. 1 link. (*c*) Chain installed in static machine. See static test No. 15. (*d*) Broke No. 1 link through weld. (*e*) Surface fracture in all links. Chain installed in static machine and broke No. 2 link at about 241,000 lbs. (*f*) Broke No. 4 link. Section shows solid. (*g*) Chain installed in static machine. See static test No. 17.

* Abstract of discussion on a Paper read before American Society for Testing Materials.

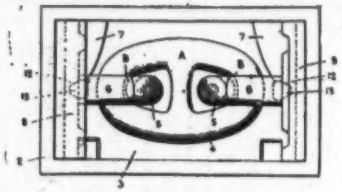


FIG. 1

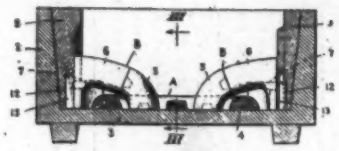
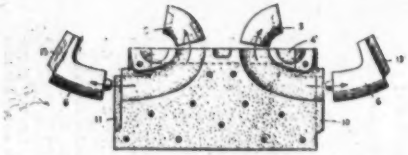


FIG. 2



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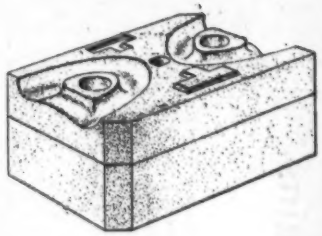


FIG. 4

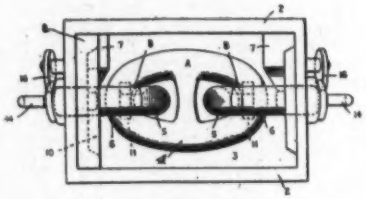


FIG. 5

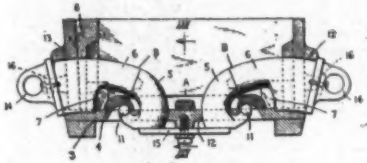


FIG. 6

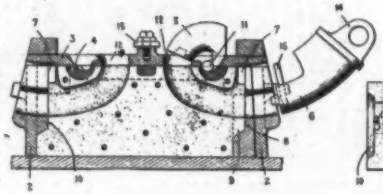


FIG. 7

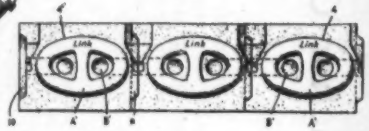


FIG. 8

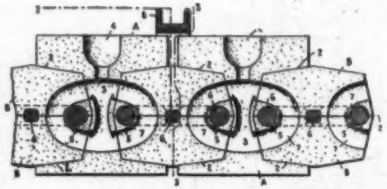


FIG. 9

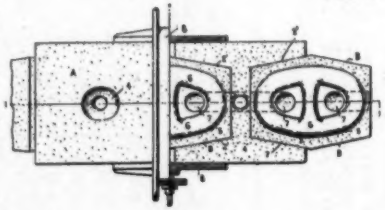


FIG. 10

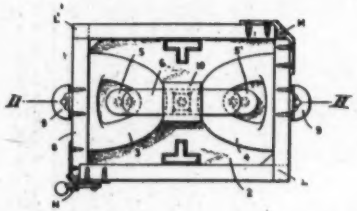


FIG. 11

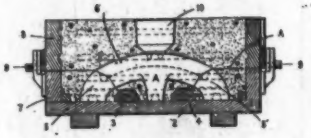


FIG. 12

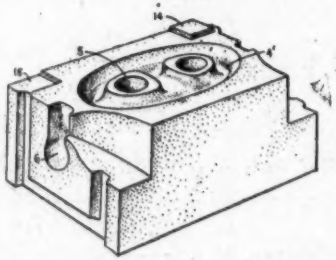


FIG. 13

FIG. 14

1,000,000 lb. capacity, and a standard Master Car Builders' drop testing machine. The chains subjected to static tension tests were supported by coupling each end link of the test chain to the crosshead of the static testing machine by means of a testing shackle and pin, as shown.

Test chains consisting of five common stud or A links were subjected to a light load sufficient to reduce high bearing spots between adjacent links, which was then released and a measurement over the three middle links laid off. The elongation over this measurement was then taken at loads corresponding to the proof load, the breaking load, and the breaking load plus 40 per cent., as specified by the ship classification societies for the corresponding sizes of wrought chain. After these three loads had been applied, released, and elongation measured, a load to destruction was then applied.

Test chains consisting of two sections of A, B, and E links, coupled with shackle D, were tested in the same manner, except that the elongation measurement was taken over the two B links. The 2¾-in. chain consisted of one each of the A, B, and E links, and the elongation was measured on the B link only.

The tests chains used in the drop testing machine were all of the 2-in. size, and consisted of five stud or A links each. These chains were installed in the testing machine by connecting the upper link in a shackle bar and the lower link in an equaliser shackle by means of shackle pins passing through the eye of each link. This arrangement is such that a part of the energy of the falling weight is transmitted to the test chain as a dynamic tensile stress. The over-all measurement of the middle three links of these test chains was laid off, as in the static tests, and the elongation measured after the third blow from each of the specified heights. The weight of the tup was 1,640 lbs., and this weight was allowed to rest upon the equaliser when readings were laid out and elongation measured. In all these tests the numbering of the links was upward, commencing with the bottom link as No. 1.

FIG. 15.—STATIC TENSION TESTING MACHINE.

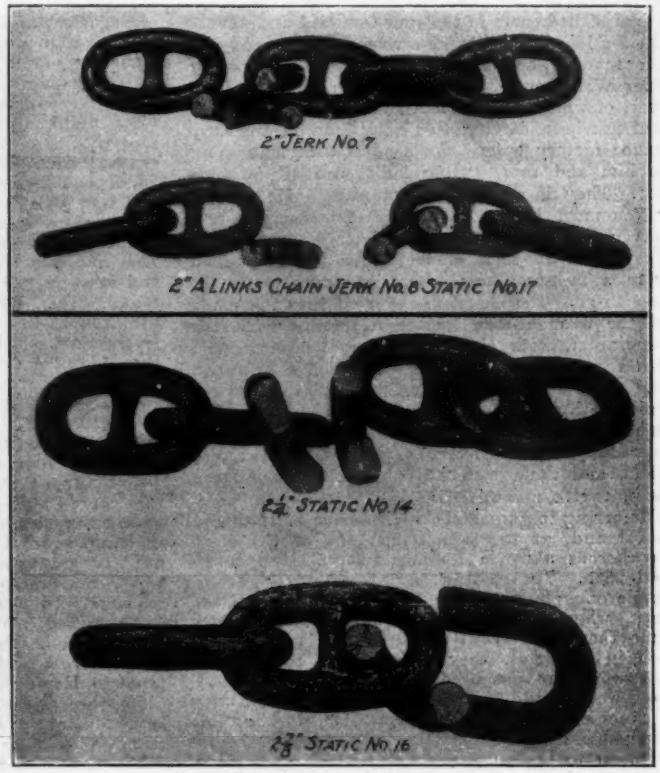


FIG. 16 (UPPER).—CAST-STEEL ANCHOR CHAIN AFTER BEING SUBJECTED TO HEAVY JERKS AND PULLS. FIG. 17 (LOWER).—CAST-STEEL ANCHOR CHAIN BROKEN IN STATIC TENSION MACHINE.

WE are informed that a new 60-ton open-hearth steel furnace has been successfully gassed at the new Penistone Works of Cammell, Laird & Company, Limited. This is one of the six steel furnaces being built for them by Wellman, Seaver & Head, Limited, of London.

The Casting of Alloys.

"The Casting of Gunmetal, Phosphor Bronze, etc.," was the subject of a Paper given at a recent meeting of the Birmingham Local Section of the Institute of Metals, by Mr. H. Gingell, I.S.O., Muntz's Metal Company, Limited. Professor T. Turner presided.

Mr. Gingell said that his aim was to show what occurred in gunmetals, phosphor bronze and other alloys of that class in cooling, and to recommend a remedy for the troubles which occurred. The scientist had come to the founders' aid and taught them a lot; but as far as a remedy was concerned, the founder became responsible. Just after the Boer War there came into use an aluminium alloy fuse, of which millions had since been made. They had not been casting this alloy long in the Ordnance factory before the head foundryman came to him and said, "Our ladles are all running out. They do not last ten minutes." He replied, "You must have some wrong metal; try a fire-clay wash"; but the trouble still continued. They tried all sorts of metal for ladles, and all were a failure, the wrought-iron ones being the first to go. The chemists reported that the oxide on the wrought-iron formed a thermit with the aluminium, with the result that sometimes the ladles would not last more than five minutes. The moulder found out that ladles made of wrought-iron oxidised very rapidly, and then it struck him (Mr. Gingell) that cast-iron did not so readily oxidise. Some cast-iron ladles were made, and these lasted six, eight, and in some cases, twelve months.

Referring to gunmetal, this was one of the most useful and, at the same time, one of the most treacherous alloys a founder was called upon to deal with. The casting of ordinary fittings was simple enough, but when they came to high-class work, where varying thicknesses occurred, then came the tug-of-war. If they went beyond one inch in thickness, they must expect segregation if means were not used to prevent it. Most of their work would be with castings in which the thicknesses varied, and he proposed to show, as far as possible, how necessary it was that means should be taken to prevent the trouble which took place in any casting where inequality of design existed. The designer should be aware of the necessity of parts which went to build up the main casting being in harmony. By that he meant, as near as possible upon an equal basis. If that was done, it would do much to help the founder, and would mitigate the possibility of segregation. It was quite clear that the alloy had not chemical unity in any sense, as the parts which made it up were adrift as far as the combining weights were concerned. Thus, on cooling Nature asserted itself, and separation took place. This was the main trouble to be grappled with.

Take any casting which was under stress or strain when in use. For instance, a wagon for a draw-bench would break down one day when in use, and the cause would be put down to weakness in design, and the thickness at the broken part increased. That was a fatal mistake; it was adding further weakness, because the chances of further segregation were increased. If one examined the fracture of the broken part, there would be found a disorganised mass of metal of all colours, as rotten as a pear, which would not give six tons to the square inch.

At the works where he was they used gun-metal screws for draw-benches. Some of these screws would run fairly well and last a reasonable time, but others would wear out very quickly. He cast a screw, using a special treatment to prevent the segregation, and this screw had been in use seven months and was still running. The metal was perfectly sound and homogeneous, and possessed its full strength and full resisting power.

Dealing with a nut for a friction press supplied by a well-known firm of engineers, Mr. Gingell said that two or three nuts were broken in succession, each fracture plainly showing that the metal had segregated to a large extent. After repeated delay, owing to a breakdown, it was arranged to supply a nut cast in his company's foundry, to be machined by the engineering firm. This nut was treated by his special process, and had been in use about five months, and was still sound. This, he said, proved that the cause of the trouble lay in the separation of the metal. In the nuts which broke the breakage occurred at the beginning of the thicker part, just where the jam came.

The method he adopted to avoid this was described by Mr. Gingell: Taking the cast of a nut, he showed that the core consisted of an iron tube or "barrel" which had small openings. About two or three minutes after casting, water was poured by a funnel into the core. The water got away through the ventholes, and oozed through the band against the metal. The water cooled the nut and prevented it reaching the temperature at which the different parts of the alloy began to separate. In that way a perfectly sound casting was obtained. With a nut of that size the thickness would be about three inches and the length of the core about six inches. It was very important to keep the tube constantly full of water while the casting was cooling. If the tube were kept constantly full the casting was sure to be sound.

The next illustration was that of a metal roller used in the manufacture of gunpowder. The roller was 4 ft. long and 12 ins. in diameter. Founders would admit that this was a most difficult thing to make and to get sound. The barrel forming the core was similar to that in the previous example. Indeed, except in castings of large size, their practice was never to feed any casting; they always had the head sufficiently high to enable the feeding to go on automatically. In making the mould they used up to about 2 ft. of special sand or loam, four parts of new, four parts of old, and one of plumbago, all well ground. The mould must be rammed thoroughly sound, or more than that, or the metal would eat into the sand—though there was a remedy for that. They used grids such as the loam moulders used. Then, taking a ring, about 1 ft. long, one of the grids was inserted, the ring was put in and rammed up with the other part of the mould. In addition

to the pipe down the centre, there was another pipe through which water was poured, and this percolated into the ashes surrounding the outside of the thick part of the casting. The water was poured down the centre about three minutes after casting, and down the other pipe about thirty minutes later. The water in the centre caused the casting to shrink towards the centre, whilst the chilling effect of the water outside prevented segregation there. By this means the produced a casting which was absolutely sound and showed no trace of segregation in any part. To prevent segregation the casting must be constantly cooled by the water. They must, as it were, keep in front of the 500 deg., or there would be trouble. Where precautions were not taken they would have, with castings of such a design, separation of the tin with a certain amount of copper, which the trimmer could cut off with his chisel.

He remembered as a lad observing the trouble this sort of thing caused to the moulders. In making such castings they would have two heads and feed them with the rod, and when the castings were got out of the sand there would be found, about 1 ft. up, a mass of metal. The men did not know what had occurred; they used to say the mixture had got out. He had known that separation to take place right through the core, and they had to drill it out.

He had stated that they would get separation with castings of 1 in. and upwards; but in the case of cylinders for a torpedo gas engine it had taken place with a thickness of only ¼ in. These cylinders had a working pressure of 500 lbs. per square inch, but they were tested up to 2,500 lbs., and in two of the cylinders the ends blew out. The alloy of which they were made was phosphor bronze, 87 per cent. of copper and the remainder tin, containing 5 per cent. of phosphorus.

The method described dispensed with feeding; also it made a general saving, whilst, better still, the constitution of the alloy was perfect. What happened with this method was that one hastened the cooling—in fact, forestalled Nature—and prevented he alloy reaching the critical stage when separation took place.

In dealing with a hydrant ram cast on the flat, the water was introduced at one end through a core similarly arranged as in the other cases. A similar method was used in casting a 5-in. gun recoil carriage twin cylinder. Equality of thickness was impossible in the later design, the thicknesses ranging from ¼ in. to 6 ins. Five hundred of these castings were made and proved satisfactory. He pointed out the futility of the mechanical tests obtained from castings in which this trouble had taken place. The test bar might be quite all right, but this result was no indication of the strength of the material in the casting. This seemed to him a most serious matter, as they would at once admit. The question should be dealt with, he said, by those responsible, or some day there would be trouble. As far as he could remember, it had never been seriously dealt with.

Phosphor bronze was a most difficult metal to deal with in the foundry because, owing to the presence of phosphorus, the metal so soon became burnt, and was thus rendered useless. In greensand work, the moulds should be rammed well, and his own practice was to rub plumbago on to the face of the mould. The metal, when it came out for pouring, was very pretty to look at. When that appearance began to cease, the mould should be poured, and very good results would be obtained.

In conclusion, Mr. Gingell said that the defect of which he had shown the remedy was one which few founders troubled about, the main object being to get work out without too much regard to excellence of material. Such a system was all very well in dealing with castings of a general or ordinary character, but when tests were laid down in specifications these must be complied with. The usual thing was that the founder, as long as the test-bar gave correct results, did not trouble about the casting; the result of the test was enough for him. Why should there be the remotest possibility of the changes which did and would take place on cooling when they had an effective remedy? He had done his best to explain the methods he had adopted, but in speaking to practical founders he would warn them to use care in its application. It was one of those things to the use of which one must grow. He added that if anyone wished for further information on the subject, the firm (Muntz Metal Company, Limited) would supply it.

Discussion.

THE CHAIRMAN said that, as they knew, in the copper-tin series they always had the possibility of the separation of a tin-rich constituent. Sometimes that was inevitable, according to the proportion of tin present. But in many cases it could be regulated, and in come cases, depending upon the composition, it could be altogether stopped. This tin-rich constituent was fusible, and in extreme cases would segregate out entirely in the way which Mr. Gingell had described, with, of course, very unsatisfactory results. The art of casting gunmetal and alloys of a similar character was to combine together in suitable proportions the soft alpha solid solution with the brittle and hardening tin constituent. He had a very interesting case brought under his notice a few years ago. Phosphor bronze was being cast by a firm of good reputation, but it was found that the test pieces which were cast on the larger casting gave altogether irregular results, and that if one of those test pieces was split, or cut down the middle, there were to be seen in the length of the test-bars more than two distinct shades of colour and character of product. The test pieces were analysed carefully to see whether there was any difference of composition, and in this respect the parts were found to be identical. But when they were examined under the microscope they exhibited entirely different structures, whilst the tensile strength and reduction in area varied along the length of the pieces themselves; one end was quite satisfactory and the other end very unsatisfactory. The piece had been cast under such conditions that one end cooled quickly, whilst the other end cooled slowly, being in contact with the large mass of hot material. There was no doubt whatever, even to the most casual observer, as to the difference in appearance and properties. The one end, being a fairly rich alloy, was of a rich reddish-yellow colour, whilst the other was greyish and tended ultimately to be a darker bluish-grey. Obviously, the difference was due to the rate of cooling, and it was found that by cooling the whole bar at the right speed, which meant cooling one part a little more quickly than it had been cooled before, the whole bar could be obtained of such a character as would pass the required tests. This

brought them to the question which Mr. Gingell had mentioned—how far did the test-bar correspond with the casting? There was no doubt that in that case the casting was much less suitable in character than were the test pieces which were attached to the casting. By cooling the casting quickly and retaining this tin-rich constituent in solution in the right amount, one retained the suitable mechanical properties of the alloy.

Mr. F. Johnson asked whether the iron barrel which Mr. Gingell introduced into the centre of his casting was readily extracted after the casting had cooled. With regard to the influence of this chill, he wanted to be quite clear as to whether it did actually hasten the rate of solidification, because he could not quite conceive of segregation taking place after complete solidification. He would like to know whether the casting was partly or entirely solid when the water was introduced. Gunmetal was a difficult alloy to deal with and to understand. Its structure depended very largely upon the rates of solidification and of cooling, and one could get all sorts of results by varying those rates. By going to one extreme—e.g., by casting a thin section in chill—one could get (in the outer shell of the casting) good mechanical tests. With a thicker section and a slower rate of cooling one got worse results as far as toughness was concerned than in a thinner casting. In that connection "under-cooling" appeared to him to play a most important part. "Under-cooling" meant that the metal fell to a temperature lower than its real freezing-point. By being retained in a condition of quietness the metal remained liquid below its actual freezing-point. Now, if the capacity for heat of the mould was such that more heat was abstracted (during this period) from the casting than could be subsequently supplied by the evolution of the latent heat—solidification when the casting did solidify—the true freezing-point of that alloy would never be reached. The result was what was known as a metastable condition; the structure was not normal, there would have been prevented in the thin section the separation of the weaker tin-rich constituent which would have taken place under the rate of cooling of the thicker section. He was afraid this explanation would appear rather involved without a micrographic illustration, but there was an extreme where the under-cooling suppressed the separation of the tin-rich constituent and produced good mechanical properties. With the slower rate of cooling, one did not get that suppression, the under-cooling did not take place to the same extent, more of the tin-rich constituent separated, and they got worse mechanical properties. Going to the other extreme to which Mr. Gingell had drawn attention, with large masses in which the separation of this tin-rich constituent was abnormal, because of segregation of the tin-rich liquid, that tin-rich liquid would yield abnormal quantities of the brittle constituent.

Mr. L. J. Mevrick said he thought he could answer one of Mr. Johnson's questions. He had made a great many microscopical examinations of Mr. Gingell's castings, and had found that the delta constituent broke up before the separation of the alpha and delta. He had examined various castings up to 4 in. or 5 in. in thickness, and had found a small quantity of delta in the central portions, but towards the outside no delta at all. The solidification, therefore, had not begun when the water began to be poured in.

Mr. H. H. Hayes said that a difficulty was experienced with regard to the casting of the 6-pdr. anti-aircraft gun cradles in Admiralty gunmetal of a composition 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc. This particular gun cradle contained two hydraulic cylinders. The micro-sections were brought to him, and he found that not only had a large proportion of the delta constituent separated out, but there was also an enormous quantity of oxide. The castings at the time were made in sand moulds, and their foundry up to that time had not had any experience in making gunmetal castings of that size. In order to make sure of getting the mould full, the foundry people made the great error of pouring very hot. At his suggestion they put iron chills at the bottom of these hydraulic cylinders, and lowered the pouring temperature. The results were splendid; they had no further trouble. When the bottoms of these cylinders were examined after putting in the iron chills, it was found that only in isolated areas was the delta constituent visible. The same trouble cropped up in the casting of the 12-pdr. cradle; this contained one large hydraulic cylinder, at the bottom of which there was a diaphragm about ½ in. thick. The same trouble cropped up again. The castings were spongy. He suggested putting an iron chill at the bottom, and again the results were very successful.

Mr. James Finlay remarked that with regard to a leaded bronze (a mixture of copper-tin-lead), it should be remembered that lead remained molten longer than the other constituents, so that great care was necessary to prevent the lead separating. Did Mr. Gingell think that his method would help to prevent this?

Mr. Gingell, in his reply, referred to the question as to how they got the barrel out. His answer was, "It falls out." That was the peculiar thing about it. In the case of the casting made on the flat he pulled the barrel out himself, and it came out quite easily. A question had been asked as to the temperature of the casting when they commenced to use the water. The water went into the barrel two minutes after casting, when the metal was in the liquid state. One could always do that with the inside, but they could not commence to deal with the outside so soon. They did not commence pouring the water for the outside until 30 or 40 minutes after. If they commenced with the outside earlier they might have trouble. In fact, to use the process one required experience. When the pouring of the water had been commenced the pipes must be kept continuously full: if the water were allowed to go down, the metal would get through the vents. It should always be remembered in using a chill that the chilled part lived on the other parts of the casting, because the rapid cooling by the contraction of the chilled part robbed the other parts of metal. In reply to Mr. Finlay, he could say that the process increased the mechanical results very much. That was quite natural, because they got the whole structure of the metal perfect throughout the casing. He had been able to get as much as ten tons yield point, 21 tons break, and 35 per cent. elongation. The composition in that case was 90/10. By using water in casting one could get a much better result with a composition lower in tin than was customary. In ordinary circumstances it didn't matter how careful one was in mixing the metals—one might use even, perhaps, 2 per cent. extra of tin than he did—but unless precautions were taken against segregation all their trouble and expense would go for nothing.

Jubilee Meeting of the Iron and Steel Institute.

The Fiftieth Annual Meeting of the Iron and Steel Institute was opened at the Institution of Civil Engineers, Great George Street, Westminster, on Thursday, May 8, M. Eugene Schneider (President) in the chair.

The Secretary (Mr. G. C. Lloyd) read the report of the Council for 1918, an abstract of which is appended.

Report of Council.

Roll of the Institute.—There were 161 new members elected during the year, the largest number added to the roll in any one year since the foundation of the Institute fifty years ago. The list of candidates for election at the autumn meeting included five ladies, all of whom were duly elected, while to the new Associate class ten new Associates were elected during the year.

The total membership of the Institute on December 31, 1918, was :—

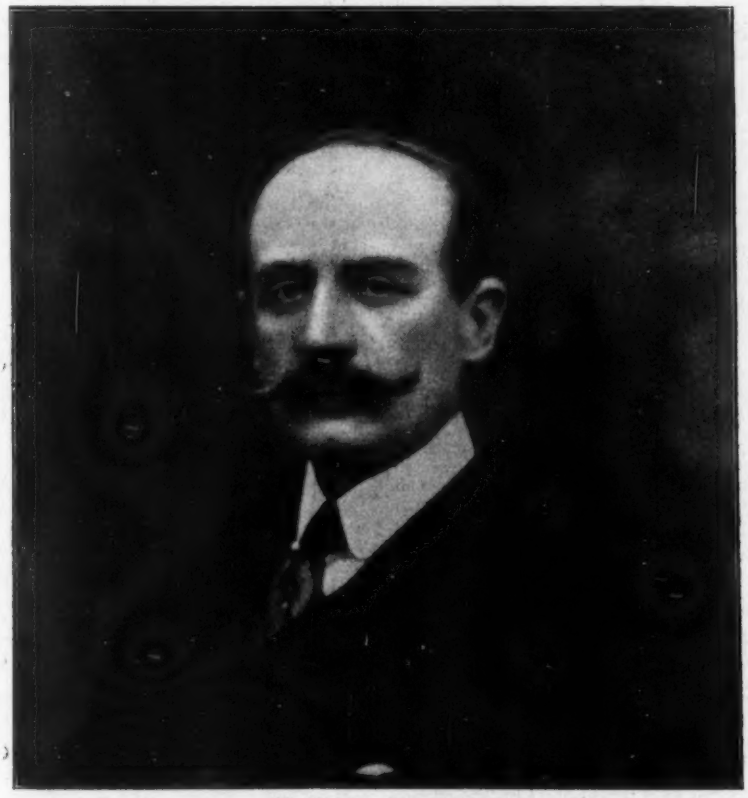
Patron	1
Honorary members	4
Life members	70
Ordinary members	1,963
Associates	60
Total	2,098

Finance.—The accounts show that the total receipts of the Institute during the year under review, but excluding the income derived from the Carnegie Research Fund, were £5,792. The expenditure during that period was £6,128. The comparative figures for recent years are as follows :—

	Income.	Expenditure.
1914	£5,310	£4,701
1915	4,816	4,275
1916	4,767	4,208
1917	5,427	5,202

The receipts on account of the Carnegie Research Fund were £1,009, and the expenditure was £530. the surplus income over expenditure being £479.

Andrew Carnegie Research Fund.—Four new applications for grants were received during the year, and awards were made to the following :—S. L. Hoyt (Minneapolis, U.S.A.), £100 for an investigation on the foreign inclusions in steel, their occurrence and identification; J. N. Kilby (Sheffield), £100 to carry out an investigation on the basic open-hearth process of steel-making, including its chemistry; G. Patchin (London), £100 to carry out research upon semi-steel and its heat treatment; J. A. Van Den Broek (Ann Arbor, Mich., U.S.A.), £100 to enable him to continue his studies upon the effect of cold working on the elastic properties of steel.



M. Eugene Schneider
(President of the Iron and Steel Institute).

Committee Work.—During the year several of the Technical Committees appointed by the Council in 1917 held meetings. An interim report on blast-furnace practice was presented by Committee No. 2 at the May meeting and discussed. Committee No. 3 has appointed

a sub-committee on open-hearth furnace design, and has held two meetings. It has also been instrumental in securing several very valuable papers on steelworks practice for reading at the meetings.

The Sub-Committee on Standard Steels appointed by Committee No. 5 has also held three meetings, and has set up an organisation whereby steelworks and their laboratories, the various universities or equivalent institutions, as well as commercial laboratories and analysts in various centres of the steel industry, will collaborate with the National Physical Laboratory in the preparation of the standardised samples. It is hoped that the various steelworks will generously provide the necessary ingots or bars for the production of the samples, and will allow their chemists and laboratories to collaborate for this purpose, free of charge. Definite promises to this effect have already been received from a number of important firms. In order to carry out efficiently the work at various centres, a number of "District Authorities" have been constituted, viz.: In London, Sheffield, Middlesbrough, Birmingham, Glasgow, and South Wales. Universities, or equivalent institutions, works and commercial laboratories in each district are represented on these bodies. The first work of the Committee will be the preparation of standards for sulphur, phosphorus, and carbon, six steels with the following approximate proportions of the elements being under selection for the preparation of the standards:—

Sulphur	0.03 and 0.07 per cent. respectively
Phosphorus	0.03 and 0.07 per cent. respectively.
Carbon (acid open-hearth) ..	0.7 per cent.
Carbon (basic open-hearth) ..	0.1 per cent.

Details of the procedure for selecting the ingots and for the preparation of samples for analysis and their standardisation have been drown up and circulated to the District Authorities.

Appointment of Representatives.—The President continues to represent the Institute on the General Committee of the Royal Society for administering the Government Grant for Scientific Investigations. Sir Hugh Bell, Bart., and Sir W. H. Ellis, G.B.E., represented the Institute on the Board of Governors of the Imperial College of Science and Technology. On the British Engineering Standards Association the Institute is represented by Dr. Arthur Cooper, Mr. G. Ainsworth, and Mr. Illtyd Williams, and Mr. Charles Dorman continues to serve on the Engineering Standards Sub-Committee for the Standardisation of Galvanised Sheets, and Mr. R. E. E. Spencer on the Sub-Committee for Special Steels for Motor-Car Construction. Mr. H. J. Yates has been appointed to serve on the Sub-Committee for Cast Iron, working under the direction of the Sectional Aircraft Committee. Sir William Beardmore, Bart., and Mr. G. Ainsworth continue to represent the Institute on the Technical Committee of Lloyd's Register of British and Foreign Shipping, and Mr. J. H. S. Dickenson represents the Institute on the Technical Committee of Motor Industries. Sir Hugh Bell and Sir Charles Allen represents the Institute on the Board of Scientific Societies of the Royal Society. Dr. Arthur Cooper was appointed to represent the Institute on the Council of the Engineering Training Organisation. Sir Robert Hadfield has been re-elected as representative of the Institute on the Court of Sheffield University, Mr. W. Peter Rylands serves in the same capacity on the Court of Liverpool University, and Mr. W. R. Lysaght, C.B.E., on the Court of the University of Bristol.

Bessemer Medal.

THE PRESIDENT, in presenting a replica of the Bessemer Medal to M. Léon Greiner, said that it was just six years ago since the original Medal was presented to M. Léon Greiner's father, Dr. Adolphe Greiner, in recognition of his eminent achievements in the metallurgy of iron and steel. In the following year Dr. Greiner honoured the Institute by accepting the Presidency. No one at that time foresaw the calamity which was destined so soon to overtake his devoted country. It was also well known how Dr. Greiner bravely faced the storm, encouraging others by his own indomitable courage and carrying on the direction of the works in the face of unheard of oppression and difficulties, and how finally he succumbed under the burden of his heavy responsibilities, and died a victim of the war and of his devotion to duty. It came to the knowledge of the Institute that he was forcibly removed from his home for a time and was treated as a common prisoner. His chateau was in the meantime occupied by officers of the invading army. On Dr. Greiner's return he found that various objects of value, amongst which was the Bessemer Medal, had disappeared, appropriated, without doubt, or, it might frankly be said, stolen by some officer of the ex-Kaiser; a practice which the Belgians and French had good reason to know was afterwards largely extended wherever the invaders set foot. The Council determined, as soon as conditions permitted, to present a replica of the Medal to Dr. Greiner's son, M. Léon Greiner, the worthy successor of his father. The new Medal differed from the original in one respect only; that was, that it bore a brief inscription engraved round the edge recording the history of the former Medal: "A replica of the Medal stolen by the Germans during their unjust occupation of Liége, 1914-1918." In the name of the Institute he presented to M. Léon Greiner the copy of the former medal, in memory of his noble father.

M. LÉON GREINER briefly responded in French.

THE PRESIDENT said that by a unanimous decision of the Council the Bessemer Medal for the year 1919 had been awarded to the eminent metallurgist, Dr. Cav. Federico Giolitti, of Turin. Dr. Giolitti was well known to the members on account of his great work on the Cementation and Heat Treatment of Steel. Unfortunately he had been detained by pressing engagements which had prevented his attendance that day, and it was proposed to postpone the presentation of the Medal to a future occasion.

New Annual Prize Medal.

THE SECRETARY said he had been asked by the President to announce that the Council had received from the Prime Warden of the Court of the Worshipful Company of Blacksmiths an offer which was contained in the following resolution passed at a meeting of the Court of the Company on October 3 last: "That the freedom of the Worshipful Company of Blacksmiths, together with a Gold Medal bearing the Arms of the Company, be presented annually to a student or to a contributor of a Paper to the Iron and Steel Institute. The award will be at the discretion of the Council in consultation with the Warden of the Court of the Blacksmiths' Company."

DR. A. COOPER announced that a large number of the members of the Council were present yesterday at a very pleasing ceremony when the Prime Warden and Court of the Worshipful Company of Blacksmiths presented the freedom of the Company to the President (Mr. Eugene Schneider) and to the immediate Past President (Sir William Beardmore). The resolution of the Company really amounted to a closer association between the Company and the Institute, and he was sure that nothing but good could result from such an association. He had great pleasure, therefore, in proposing a hearty vote of thanks to the Blacksmiths Company.

The motion was carried unanimously.

Queries.

Utilisation of Waste Heat.

The writer is contemplating the erection of a modern casting foundry, and wishes to ask if any of your readers have had practical experience of utilising the waste heat of the cupolas for raising steam for heating and other purposes at low pressures.—"ENGINEER."

The Electric Furnace in the Foundry.

At a joint meeting of the Iron and Steel Institute and the Institution of Electrical Engineers held in London on Thursday, May 8, a series of papers was presented dealing with the use of electric furnaces. Particular interest attaches to these papers, in view of the large extension of electrical furnace working for melting metals in the foundries of the United States. It will be noticed that Mr. Mercer, who was in charge of the electric steel furnace department of the Ministry of Munitions, in his paper, gives a number of tables showing the results obtained in making castings.

TABLE I.—*Electric Steel Furnaces in the United Kingdom.*

Make.	Number of furnaces.	Total tons, size.	Total k.v.a.	Nominal tons output per month.
Electro-metals ..	27	73	20.274	6,740
Greaves-Etchells ..	26	64½	18,830	5,680
Héroult	45	180½	43,220	13,760
Rennerfelt	4	7	1,895	750
Snyder	6	9½	3,150	1,200
Special	2	2	750	280
Stassano	2	2	600	240
Stobie	5	45½	10,050	2,600
Total	117	384	98,769	31,250

Electric Furnaces in the United Kingdom, 1918.

By R. G. Mercer.

In preparing this short Paper which deals chiefly with the operation and output of the various types of furnaces under actual working conditions, the author wishes at the outset to make it clear that while he is anxious to render the data given as intelligible as possible, he obviously cannot give the names of the users; so, in the tables given below, the furnaces are all numbered and will doubtless be recognised by their respective owners. Furthermore, he cannot, in his present position, show in these tables the makers' names. The data given will, however, show users whose furnaces are not operating as well as they may wish, what their performance and output should actually be. The author's main object is to give any information possible which may tend to increase the general efficiency of electric steel furnaces.

There are installed or being installed 141 electric furnaces with a total capacity of 112,000 k.v.a. Of these, 24 are or will be used for Swedish substitute, cupro nickel, allundum, manganese copper, and ferro alloys. The remaining 117 are electric steel furnaces having a total charging and k.v.a. capacity of 384 tons and 98,769 k.v.a. respectively, and a total nominal output of 31,170 tons per month, based on 5 days a week, 4 weeks per month.

Assuming that all these furnaces are working at full load, the total nominal output at the end of a year would be 405,000 tons. It has to be borne in mind, however, that some furnaces only work on day shift, others are shut down or not yet installed, and all those in commission have delays due to furnace or electrical troubles and shop conditions. These delays were in many cases very frequent and serious.

Electric steel furnaces are used for steel castings and ingots, and the following tables give particulars of each and the total number, capacity, etc., of each type of furnace. It will be noted that the Héroult furnace (which was first in the field) heads the list so far as number of furnaces and capacity are concerned. The Electro-Metals furnace which shows the next highest returns came on the market later. The Greaves-Etchells, which was produced some time after the Electro-Metals, comes third on the list, and the Stobie furnace, which comes fourth on the list, has only comparatively recently been offered to the steel trade. The Snyder furnace, which is used for making acid steel, has to rely largely on the steel maker's requirements as to whether he wants to make acid or basic steel. The two furnaces marked "Special" were made by the user.

The nominal output in tons per month is based on 5 days a week, 4 weeks a month, and the rated charging capacity of the furnace. It will be noted, however, especially in the case of 6-ton furnaces, that the actual charge is in most cases greater than the rated charge. The actual output giving the best month's

TABLE II.—*Castings: Electric Furnaces (Installed).*

Make.	Number of furnaces	Tons, size.	Total k.v.a.	Tons output per month.	
				Nominal.	Actual.
Electro-metals	13	25½	8,139	2,900	—
Greaves-Etchells ..	4	7	2,050	700	—
Héroult ..	7	16	4,150	1,500	—
Rennerfelt ..	2	5½	1,100	440	—
Snyder ..	6	9½	3,150	1,200	—
Special ..	2	2	750	280	—
Stassano ..	2	2	600	240	—
Stobie ..	1	5	800	400	—
Total ..	37	72½	20,739	7,720	say 5,019

TABLE IIA.—*Castings: Electric Furnaces (to be Installed).*

Make	Number of furnaces.	Tons, size.	K.v.a.	Tons output per month.	
				Nominal.	Actual.
Electro-metals	1	2	800	280	—
Greaves-Etchells ..	4	17	5,450	1,260	—
Héroult ..	4	10½	2,700	980	—
Stobie ..	2	13½	3,250	600	—
Total ..	11	44	12,200	3,120	say 2,028
Grand total	48	116½	32,939	10,840	say 7,047

TABLE III.—*Ingots: Electric Furnaces (Installed).*

Make.	Number of furnaces	Tons, size.	K.v.a.	Tons output per month.	
				Nominal.	Actual.
Electro-metals	12	39½	10,335	3,200	—
Greaves-Etchells ..	10	14½	4,710	1,570	—
Héroult ..	32	148½	34,920	10,720	—
Rennerfelt ..	1	2	600	240	—
Stobie ..	1	12	3,00	800	—
Total ..	56	217	53,565	16,530	say 12,906

TABLE IIIA.—*Ingots: Electric Furnaces (to be Installed).*

Make.	Number of furnaces.	Tons, size.	K.v.a.	Tons output per month.	
				Nominal.	Actual
Electro-metals	1	5	1,000	360	—
Greaves-Etchells ..	4	22	4,900	1,650	—
Héroult ..	1	3½	750	280	—
Stobie ..	1	15	3,000	800	—
Total ..	7	44½	9,650	3,090	say 2,10

output of each furnace is purposely taken, and is 65 per cent. of the nominal output (see Table II.). Assuming that the furnaces to be installed have an actual output of 65 per cent. in Table II., the actual output per month would be 2,028 tons, making a total of 7,047 tons per month, or 91,637 tons in the ladle per annum,

TABLE IIIB.—*Furnaces (not Working) November*, 1918.

	Number of furnaces	Tons, size.	K.v.a.	Tons output per month. Nominal.	Actual.
Greaves-Etchells ..	4	3½	1,720	500	—
Héroult ..	1	2½	700	220	—
Rennerfelt ..	1	½	195	70	—
Total ..	6	6½	2,615	790	say 716

for castings, against a total nominal output of 140,920 tons per annum. It will be readily seen from the above figures that the furnaces are mostly working on day shift (see Table IIA). The actual output is purposely taken from the best month's output of each furnace, and is 78 per cent. of the nominal output (see Table III.). Assuming these had a ratio of 78 per cent. actual to nominal output as above, the actual output would be 2,410 tons per month (see Table IIIA.).

These furnaces represent those sanctioned by the Ministry of Munitions of War and do not include those ordered since November, 1918, after which date sanction was not required. The actual output would be 716 tons per month on the above assumption. (Table IIIB).

These figures go to show that, on the above assumption, we have in this country furnaces capable of producing a total possible output of over 300,000 tons of electric steel per annum with 98,769 k.v.a. behind them. Taking the average output per month over a period of time we get very different results, as follows :—

	Nominal.	Actual.	
Castings	7,720	3,557	46 per cent.
Ingots	16,530	9,855	59 per cent.

Electric Furnace Log Sheets.

On visiting the various steel works in this country the author found that while some users kept proper records of the operation and output of their furnaces, others confined themselves more to the output and kept no proper records of current and electrode consumption or causes of delays. Some indeed appeared to treat these as a matter of course, notwithstanding their anxiety to get output. This sort of feeling was good neither for the electric steel trade of the country nor for the maker or designer of the furnace. When keen competition set in, the steel-maker might find his furnace out of commission and, unless the furnace-maker made his furnace as fool-proof, reliable, and efficient as possible, he would find he was doing harm not only to the electric steel trade development in this country but also to himself in particular.

It was decided therefore to send out electric furnace log sheets to all users and to ask for weekly returns to be made to the Ministry of Munitions. This sheet was based on the Héroult furnace log sheet of which Mr. Campbell kindly supplied a copy.

To meet the wishes of the steel-makers, who rightly pointed out that while anxious to give the Ministry the fullest possible information it was very difficult, especially where several furnaces were installed, to find time or staff to fill them in, in view of the number of other returns they already had to make to different Departments of the Ministry, this log sheet was later replaced by a fortnightly return with condensed particulars. The main difference between the two log sheets was that instead of giving full particulars of each individual heat, the total number over a fortnight is now given. These, with the particulars previously given, were sufficient for the requirements of the Ministry and enabled the latter to note especially those furnaces which were not operating well and the reason for this. The author desires to thank the electric furnace proprietors for the great trouble they have taken in making these returns as complete and comprehensive as possible.

From the returns given in these log sheets he has been able to insert the figures given in Tables IV. to XIV. inclusive. These figures, taken over a period

TABLE IV.—*Nominal Output* 70 *tons per month* (80 *for Castings*).

	1	2	3	4	5	6	7
K.v.a.	250	250	260	250	250	250	250
Size, tons	¼	¼	¼	½	¼	¼	¼
Period, months	1	4½	4	4	8½	5½	5½
Class of steel	HS	HS	Carb.	HS	Cgs.	Cgs.	Cgs.
Number of slags	2	1	1	1	1	1	2
Number of heats	51	313	243	244	163	366	133
Number of hours	149	699	569	316	396	633	498
Number of tons	25	157	136	125	175	176	70
Average :							
Time per heat, hours	2.9	2.23	2.34	1.3	2.43	1.73	3.74
Time per ton, hours	5.9	4.45	4.18	2.57	2.26	3.59	7;10
Tons per heat	0.49	0.5	0.56	0.5	1.07	0.48	0.52
Units per heat	600	443	670	—	857	577	770
Units per ton	1,220	883	1,200	750	793	1,200	1,460
Tons per month	25	34	34	62	44	21	13
Heats per day	2.5	3.5	3	6	2	2	1.3
Best month's output	25	41	40	75	96	38	23
Units per ton	1,220	840	1,140	—	768	1,180	1,400
Heats per day	3	4	3.5	7	2.8	3.7	2.4
Electrode diameter { A	4 in.	4 in.	4 in.	5½ in.	4 in.	4 in.	4 in.
Electrode diameter { G	—	—	—	—	—	—	—
Electrode consumption, lbs. per ton in ladle	47	18	25	37	17	18	22
Delays, days	2	18	18	—	17	79	3
Basic or acid	B	B	B	A	B	B	B

All these furnaces are on day shift. No. 5 it will be noted shows an output over the best month of 96 tons. There were 56 heats during this period, so the average weight was 1.7 tons per charge in a ¼-ton furnace. The general performance of this furnace is good though the electrode consumption could be improved, and should come down to 10 or 12 lbs. of graphite per ton in ladle, even on day shift No. 4 is a case where no meter has been installed against the furnace. The current consumption is, however, estimated to be 750 units per ton.

TABLE IIIC.—*Furnaces for Castings and Ingots.*

Class of steel.	Number of furnaces	Tons, size.	K.v.a.	Tons output per month. Nominal.	Actual.
Ingots ..	69	267½	65,830	20,410	16,032
Castings ..	48	116½	32,939	10,840	7,049
Grand total	117	384	98,769	31,250	23,081

of one to six months, show the comparative performance of the same or different types of furnaces working as nearly as possible on the same class of steel and under similar conditions in the various steel works. In making comparisons the author considers it to be necessary to take furnaces having the same k.v.a. capacity and not the rated charging capacity in tons, and it will be noticed that they are entered on this basis. The heats per day in the tables are the average number of heats taken over the whole period of 20 days a month, and include delays. Under "best month's output" the average number of heats per day are shown with "no delays."

TABLE VI.—*Nominal Output* 180 *Tons per Month* (200 *for Castings*).

	1	2	3	4	5	6	7
K.v.a.	450	450	450	400	450	450	450
Size, tons	1½	1½	1½	1½	1½	1½	1½
Period, months	3½	4½	3	2	5½	5½	5½
Class of steel	Tool	I	I	Cgs.	Cgs.	Cgs.	Cgs.
Number of slags	2	2	2	1	1	2	2
Number of heats	217	220	87	151	447	238	200
Number of hours	826	1,605	431	522	1,383	842	742
Number of tons	359	357	122	222	628	368	331
Average:							
Time per heat, hours	3.8	7	4.9	3.4	3	3.53	3.7
Time per ton, hours	2.3	4.49	5.5	2.3	2.2	2.28	2.24
Tons per heat	1.65	1.55	1.4	1.47	1.4	1.55	1.65
Units per heat	1,420	1,830	1,490	1,330	1,120	1,477	1,532
Units per ton	860	1,180	1,060	950	800	955	925
Tons per month	120	79	40	110	114	67	60
Heats per day	3	3	1.4	3.7	4	2	2
Best month's output	156	100	64	125	180	94	108
Units per ton	785	1,139	920	890	770	1,000	880
Heats per day	4.75	4	2	4	6	3	3
Electrode diameter A	—	—	—	—	—	14 in.	—
Electrode diameter G	6 in.	6 in.	5½ in.	4 in.	5½ in.	8 in.	6 in.
Electrode consumption, lbs. per ton in ladle	—	—	—	—	—	170	—
	20	40	30	9	21	32	13
Delays, days	29	23	16	4	27	11½	—
Basic or acid	B	B	B	A	B	B	B

Nominal Output.

After a careful comparison of the various sizes and types of furnaces, the author has arrived at the following particulars, setting forth the size k.v.a. capacity, and nominal output of each.

TABLE IX.—*Nominal Output* 220 *Tons per Month.*

	1	2	3	4	5	6	7	8	9
K.v.a.	600	600	600	600	600	625	650	650	650
Size, tons	2	3	1½	2	1½	2	2½	4	3
Period, months	5	3½	3	3½	2	4½	5½	3	7½
Class of steel	C & Ni, CH	C & Ni, CH	I	I	HS Tool	C & Ni, CH	HS Tool	C & Ni, CH	High C & Cgs.
Number of slags	2	2	2	2	2	2	2	2	2
Number of heats	189	211	79	172	116	126	155	93	328
Number of hours	845	1,387	477	647	498	1,139	824	685	1,676
Number of tons	461	847	90	413	214	671	470	420	1,279
Average:									
Time per heat, hours	4.47	6.57	6	3.18	4.2	8.9	5.43	7.3	5
Time per ton, hours	1.83	1.63	5.2	1.56	2.3	1.69	1.75	1.6	1.3
Tons per heat	2.44	4	1.14	2.36	1.84	5.3	3	4.5	3.9
Units per heat	2.045	2,995	1,970	2,330	—	—	2,800	4,110	2,280
Units per ton	838	746	1,730	970	740	—	920	910	584
Tons per month	92	260	30	118	107	150	85	140	170
Heats per day	1.8	3	1.3	2.5	3	1.4	1.4	1.5	2
Best month's output	105	331	57	132	—	195	127	200	266
Units per ton	720	710	1,350	936	—	—	880	897	625
Heats per day	2	4	2.4	2.5	3	2	2	2.3	3
Electrode diameter A	—	14 in.	—	14 in.	—	—	—	—	14 in.
Electrode diameter G	6 in.	—	9 in.	—	6 in.	7 in.	9 in.	8 in.	—
Electrode consumption, lbs. per ton in ladle	17	60	—	60	—	17	24	26	47
Delays, days	16	7	—	26	12	39	45	26	5
Basic or acid	B	B	B	B	B	B	B	B	B

The nominal output per month is based on the assumption that the weight of charge is equal to the rated charging capacity of the furnace. In actual practice, however, this is not the case in many furnaces, as will be noticed in the tables. The 6-ton furnaces, for instance, take from 6.8 to 10.2 tons per charge on the average. Consequently the actual output is increased, though on the other hand the heat period would increase and the average number of heats per day might be less than the above estimate. The author sees no reason, however, why the above outputs should not be easily reached under proper conditions, and these call for continuity of working and reliability of plant and the efficient working of the same.

Delays.

Continuity of working greatly depends, of course, on the volume of business, but reliable and efficient working depends on the furnace being as reliable, efficient, and fool-proof as possible. Assuming it has these very rare essentials, and a gang which takes an intelligent interest in what should be regarded as a good tool, it is in turn relying on what is known as "shop conditions," such as waiting for the crane, etc. While it is difficult where there are a number of furnaces working together to arrange things so that they may be teemed as and when ready, it should not be difficult for a single furnace to get this necessary attention, for the want of which the refractories suffer, current is wasted, and the gang is kept waiting.

Failure of Electric Power Supply.—Failure due to breakdown of generating plant and lack of spare plant occurred in one or two cases. The generating stations were working at their maximum capacity and were at times severely overloaded and there were few oppor-

tunities for overhauling the boilers and other plant. The result was that when shortness of supply happened, the first plant to be shut down, with little or no notice, was the electric furnace. It used a large amount of current and was consequently easier to shut down than a lot of small and not so important users.

There is no doubt that all the users of electricity supply were doing important work during the war, but very much less consequential damage and interference would have resulted if the furnace user could have been kept going until he had at any rate a chance of cleaning his furnace so as to prevent a possibility of freezing. When it was pointed out to the electrical engineer how important it was to give the furnace user an opportunity of doing this and to find out from him how long it would take to teem, the engineer always showed his keen appreciation and, although he was in these cases at his wits' end to try to accommodate everybody, he most certainly gave the electric furnaces on his mains first consideration. The author thinks a debt of gratitude is due to the various corporations and other electric supply departments for the way they carried on under difficult conditions. Like the Navy they worked silently, and their existence was chiefly brought to mind when anything adverse happened and supply was even temporarily cut off.

Breakdown of Furnaces.—Delays due to this cause have been far too frequent. In the author's opinion the tilting gear and general arrangement of electrode feed-gear on certain types have not been designed to withstand the conditions in a steel works. He has many records of stripping on the tilting gear, resulting in very narrow escapes in some instances. He also has records of stripping of the electrode-raising and lowering gear, with the result that the gallows arm falls right down, with consequent damage to the furnace and very possible transformer troubles (referred to later).

It is very comforting to state that the makers concerned have eliminated or are eliminating these bad features. One maker has indeed redesigned his furnace and has, on furnaces now in course of manufacture, made radical alterations and improvements in these and other features. The other makers concerned are making important alterations, but it is not proposed to mention these in this paper.

If the reliability can be improved it will certainly pay the user to have his furnace brought up to date as far as possible (if he has not already done so, and

TABLE X.—*Nominal Output* 280 *Tons per Month.*

	1	2	3	4	5	6	7
K.v.a.	750	750	750	750	765	800	800
Size, tons	3½	3	3	3	2½	5	3
Period, months	1	3	4½	5	3½	5½	5½
Class of steel	I and Cgs.	C and Cgs.	I and Cgs.	I and Cgs.	Cgs.	Cgs.	Cgs.
Number of slags	2	2	2	1	1	1	2
Number of heats	42	120	224	156	305	267	189
Number of hours	212	656	1,242	815	1,178	1,111	841
Number of tons	110	354	915	427	694	1,020	579
Average:							
Time per heat, hours	5	5.46	5.54	5.2	3.86	4.1	4.4
Time per ton, hours	1.9	1.85	1.35	1.9	1.7	1.08	1.45
Tons per heat	2.6	2.95	4.08	2.73	2.27	3.8	3
Units per heat	2,630	2,620	3,700	2,670	1,820	3,300	3,120
Units per ton	1,000	955	900	977	800	866	1,050
Tons per month	110	118	203	85	198	185	105
Heats per day	2	2	2.5	1.5	4.3	2.4	1.7
Best month's output	—	195	260	97	237	223	128
Units per ton	—	945	940	1,000	720	810	1,020
Heats per day	2	3.3	3.5	1.8	4.8	2.8	2
Electrode diameter A	14 in.	—	14 in.	14 in.	—	—	—
Electrode diameter G	—	8 in.	—	—	8 in.	9 in.	8 in.
Electrode consumption, lbs. per ton in ladle	—	23	90	70	12.6	6.5	16
Delays, days	7	27	34	8	9½	16	20
Basic or acid	B	B	B	B	B	B	B

It will be noted that whereas No. 5 was in actual operation on the average 19.6 hours per day with an average output of 198 tons per month, No. 6 working 11.8 hours a day gave an average output of 185 tons per month. The electrode consumption of 6.5 lbs. includes breakages.

TABLE XI.—*Nominal Output* 280 *Tons per Month.*

	1	2	3	4	5	6	7	8
K.v.a.	750	750	750	750	800	800	850	900
Size, tons	3	3	3½	3	3	3	3	3
Period, months	2	2	3½	3½	4½	3	3½	4
Class of steel	I	I	CH and Ni, CH	I	I	C	Ni, CH Mang.	1 and Cgs.
Number of slags	2	2	2	2	2	2 & 1	2	2
Number of heats	156	112	150	205	77	90	100	114
Number of hours	733	547	837	865	467	625	547	754
Number of tons	487	300	523	704	293	265	354	416
Average:								
Time per heat, hours	4.69	4.8	5.4	4.2	6	6.9	5.47	6.6
Time per ton, hours	1.5	1.6	1.6	1.22	1.59	2.3	1.54	1.8
Tons per heat	3	2.68	3.48	3.4	3.8	2.9	3.54	3.64
Units per heat	2,510	2,650	3,040	2,890	4,100	2,980	4,120	3,360
Units per ton	807	990	870	844	1,080	1,000	1,160	920
Tons per month	243	150	149	300	65	88	100	104
Heats per day	3.9	2.8	2	3	1	1½	1.5	1.4
Best month's output	—	—	207	279	102	138	149	163
Units per ton	—	—	720	817	1,160	1,000	1,050	1,000
Heats per day	3.9	2.8	2.4	4	—	2.5	2	2½
Electrode diameter A	—	14 in.	—	—	14 in.	—	—	16 in.
Electrode diameter G	8 in.	—	8 in.	8 in.	—	8 in.	9 in.	—
Electrode consumption, lbs. per ton in ladle	—	—	15	13	97	—	22	65
Delays, days	—	—	—	19	34	102	15	57
Basic or acid	B	B	B	B	B	B	B	B

No. 6—Three months' working period from 5th Oct. to 22nd Feb., 5½ months.
No. 7 has had 281 tons' output at 925 units in the month, working 19.6 hours per day, 4.8 heats per day.

there are cases where this has happened). The result will be that the user can concentrate on making steel without much fear of breakdowns. He will turn the steel out at a cheaper rate per ton, for he will not only save all the "kilo-units" used for heating up, but will also reduce his electrode consumption and prolong the life of the roof and linings.

Water-cooled Collars.—These at the electrode entrance in the roof have been a source of constant trouble and delays. Their breakdowns are unhole, and it does not console the user, even if he is making high carbon steel, to have such happenings. The author knows of a case where over 1½ cwt. of amorphous carbon was used to the ton of steel in the same, which was immediately made into scrap ingots. Table XVI., showing the total amperes which amorphous or graphitic carbons should carry at a current density of about 25 and 100 amperes per sq. in. respectively, may be of use.

There is no doubt whatever that some of the exist-

TABLE XII.—*Nominal Output* 380 *Tons per Month.*

	1	2	3	4	5
K.v.a.	1,200	1,200	1,200	1,200	1,200
Size, tons	6	7	6	6	6
Period, months	3½	1½	4½	2	3½
Class of steel	Ni, C.H	Ni & C	I	I	I
Number of slags	2	2	2	2	2
Number of heats	171	70	116	67	128
Number of hours	1,373	574	1,203	745	1,100
Number of tons	1,501	517	1,183	478	873
Average:					
Time, per heat, hours	8	8.2	10.37	11.1	8.5
Time per ton, hours	0.91	1.1	1.017	1.56	1.26
Tons per heat	8.77	7.4	10.2	7.13	6.8
Units per heat	5,710	6,899	9,056	7,080	6,870
Units per ton	650	934	896	995	1,000
Tons per month	462	413	252	239	267
Heats per day	2.6	2.8	1.3	1.7	2
Best month's output	552	—	435	338	299
Units per ton	647	—	800	957	990
Heats per day	3	—	2	2.35	2
Electrode diameter { A	18 in.	20 in.	20 in.	18 in.	18 in.
Electrode diameter { G	—	—	—	—	—
Electrode consumption, lbs. per ton in ladle	30	45	86	130	—
Delays, days	5	4	56	15	—
Basic or acid	B	B	B	B	B

No. 1 gave 552 tons in 63 heats of 480 hours in one month. The electrode consumption is excellent for amorphous carbon.
No. 3 furnace had electrical troubles; also electrodes were the chief causes of delay. No. 4 electrodes gave great trouble and caused great delays.

doubtedly due chiefly to failure of water supply, but many installations are now complete with a tank placed above in a suitable position, the tank being kept filled from the water mains or other source, so that in the event of the main supply being shut off for any reason, there is a sufficiency to carry on with.

Electrode Holders.—Electrode holders of certain types also give a lot of trouble. Personally, the author has little or no use for a water-cooled electrode holder; for, in his opinion, its use is an admission that it is exposed to the hot gases coming through the roof at the electrode entrance, which therefore has no suitable economiser or seal, or that it has not a proper electrical contact around the electrode. If electrodes (and especially amorphous carbon) are operated at a proper current density, and assuming they are not of inferior quality, the holder should be able to carry the necessary current without undue heating. Against this it may be argued, and with some reason, that at 5,000 amperes per phase. It may further be argued (and again with some reason) that amorphous carbons are very often of inferior quality. This is the case, and it very often happens that while one batch may be good the very next batch out of the same heating furnace may be very inferior. Everyone who has used them knows what he may expect. It is not comforting for lumps of, say, 18-in. carbon to break off in the furnace. It is not easy to take them out of a 14-in.

Water-cooled Collars.—These at the electrode entrance in the roof have been a source of constant trouble and delays. Their breakdowns are unwhere, say, a furnace is fitted with 14-in. amorphous carbons, which at a current density of 25 amperes per sq. in. should carry about 4,000 amperes each, the user nearly always runs them at 5,000 or 6,000 amperes. The user may say, in explanation, that he cannot otherwise get his heat in the furnace (there is plenty outside). The answer is that he should either put in a larger electrode if the furnace can take it or one be got for, say, 8-in. graphite, which with a current density of 100 amperes per sq. in. will enable him to run

TABLE XIII.—*Nominal Output* 420 *Tons per Month.*

	1	2	3	4	5
K.v.a.	1,800	1,800	1,875	1,500	1,500
Size, tons	7	6	8	7	7
Period, months	11½	2½	1½	3	2½
Class of steel	Ni, CH	I	I	I	I
Number of slags	2	2	2	2	2
Number of heats	331	114	45	104	105
Number of hours	3,015	756	415	1,048	1,063
Number of tons	3,045	786	437	748	953
Average:					
Time per heat, hours	9.1	6.63	9.2	10	10.1
Time per ton, hours	0.99	0.96	0.95	1.4	1.11
Tons per heat	9.2	6.9	9.7	7.2	9.07
Units per heat	8,700	5,710	9,000	7,450	6,500
Units per ton	945	828	925	1,035	715
Tons per month	265	314	292	249	381
Heats per day	1.5	2.3	1.5	1.7	2.3
Best month's output	400	372	365	300	422
Units per ton	950	800	940	1,000	677
Heats per day	2	2.7	2	2	2.4
Electrode diameter { A	18 in.	—	20 in.	20 in.	18 in.
Electrode diameter { G	—	12 in.	—	—	—
Electrode consumption, lbs. per ton in ladle	65	—	44	—	100
Delays, days	77	—	10	—	11½
Basic or acid	B	B	B	B	B

ing types of electrode holders are fairly reliable and efficient (without water cooling) where a reliable electrode economiser is fitted. The great difficulty is to find an economiser which will stand up in existing furnaces of the gallows-arm type fitted with amorphous carbon electrodes. In existing furnaces the gallows arm comes down so close to the roof that a comparatively shallow economiser has to be employed.

The makers of the Greaves Etchells furnace were, the author thinks, the first to tackle this problem seriously, and they were followed immediately by the makers of the Electro-Metals and Héroult furnaces. Many types have been tried, with good, bad, or indifferent results.

The problem is nothing like so difficult with graphitic carbon electrodes, as these do not suffer from oxidation to anything like the same extent.

TABLE XIV.—*Nominal Output 600 Tons per Month.*

	1.	2.
K.v.a.	2,500	3,000
Size, tons	10	12
Period, months	3½	6½
Class of steel	Ni, CH	Ni, CH, and C
Number of slags	2	2
Number of heats	106	331
Number of hours	818	2,039
Number of tons	900	3,575
Average:		
Time per heat, hours	7.7	6.16
Time per ton, hours	0.9	0.57
Tons per heat	8.5	10.8
Units per heat	8,200	9,657
Units per ton	966	890*
Tons per month	257	572
Heats per day	1.5	2.6
Best month's output	357	791
Units per ton	945	869
Heats per day	2.3	3.6
Electrode diameter (A)	18 in.	—
Electrode diameter (O)	10 in.	10 in.
Electrode consumption, lbs. per ton ladle	30	12.9
Delays, days	—	29
Basic or acid	B	B

* Includes all steelworks' auxiliaries, and the rating would be 700 tons per month on the basis of 3 heats of 12 tons, say 35 tons per day, 20 days per month. This furnace has had as much as 1,010 tons' output in one month in 1917.

TABLE XV.—*Ratings of Electric Furnaces.*

Ingots or castings.	Size, tons.	K.v.a.	Average hours per heat.	Number of heats per day.	Nominal tons per month of 20 days.
Ingots	¼	250	2.75	7	70
Castings	¼	250	2.25	8	80
Ingots	1½	500	3.25	6	180
Castings	1½	500	3.0	7	200
Ingots	2–2½	650	..25	5	220
Castings	2–2½	650	3.5	5	240
Ingots	3–3½	850	5.75	4	280
Castings	3–3½	850	4.75	4	280
Castings	5	1,000	4.0	5	500
Ingots	6	1,500	7.5	3	360
Ingots	7	1,800	7.5	3	420
Ingots	10	2,500	7.5	3	600
Ingots	15	3,000	7.5	3	900

Economisers which were unsatisfactory with amorphous carbon behaved well up to a certain point, but fell down either due to failure of the water supply or because the man in charge neglected to look after them. These self-adjusting economisers demand attention periodically, and are not sufficiently fool-proof. The author's view is that after the maker has done his best to improve an existing furnace by such an addition, it is up to the user to see that proper care and inspection of the same are practised. The whole question of "human element" is by far the most important in the operation of a reliable furnace.

Of the gallows-arm type of furnace the Snyder can claim over a period an electrode consumption as low as 7 lbs. of 4-in. graphite per ton of steel in ladle. The Héroult, Greaves-Etchells, and Electro-Metals, have with economisers each shown a graphite consumption, over a period, of 13 lbs. per ton, which is good, but will, the author hopes, be improved still further. Of the furnaces having no gallows arm the Stobie shows an electrode consumption of 9-in. graphite as low as 6.5 lbs. per ton over a period of 5½ months.

Low-tension Conductors.—These have not in all cases received the necessary attention in the past. The author's opinion is that a current density of 750 amperes per sq. in. is ample for copper strip, for they are nearly sure to be run at a higher rate in actual practice. The maker should himself be responsible for all joints being properly made in the first instance and should instruct the user to have them periodically inspected.

Talks with the qualified electrical engineer in charge on I^2R losses, reactance, etc., may be very useful, but to the ordinary man a knowledge that hot joints mean bad joints has, to the author's knowledge, had greater practical effect.

Transformers.—These are, after all, the most important part of the furnace installation, for a breakdown of one (unless there is a spare at hand) involves in nearly all cases a considerable delay of anything up to, say, 2 months. Until recently, two transformer makers have had the bulk of the furnace business. Breakdowns of both makes have occurred. In the early days these were no doubt due to the fact that the makers did not appreciate (as they did very soon after) the very heavy service their apparatus would be called upon to stand up to. They did not know what heavy surges the transformers would be liable to during the melting-down period; on the other hand, transformers were in some cases of insufficient capacity. The furnace maker may have felt that the guarantee of 20 per cent. overload continuously would make them ample. At any rate breakdowns occurred. The transformers were then greatly improved both mechanically and electrically and by degrees transformers of a bigger k.v.a.-capacity were installed, but, notwithstanding all this, breakdowns, though less frequent, happened owing to causes quite outside the transformer maker's control. Here are two examples:—(1) A furnace had practically a dead short circuit and the oil switch which was close to the furnace refused to trip, the gear being choked with grit. (2) The transformer was placed in a chamber underground which had forced ventilation but no spare motor-driven fan. The fan failed for want of oil, and the furnace carried on till the transformer failed.

TABLE XVI.

Diameter of electrode (in.).		Amperes per electrode.	
Graphite.	Amorphous.	Graphite.	Amorphous.
5½	10	2,000	2,00
6	14	3,000	4,000
7	16	4,000	5,000
8	18	5,000	6,500
9	20	6,500	7,800
10	—	8,000	—
12	—	11,000	—

Automatic Voltage and Current Regulations.—These are going to help not only the transformers but also the power supplier. The regulators can be put into commission direct on to a cold charge without any hand control. The electrodes can be rapidly withdrawn on the occasion of very heavy overloads. The result is a very good load chart. The Woolwich Arsenal has a set running in conjunction with one of two 6-ton 2,000-k.v.a. Greaves-Etchells furnaces.

The author has confined his Paper to electric steel furnaces, and so does not propose to deal with the 24 arc furnaces referred to above. Neither does he deal with furnaces of the resistance type such as those used for carbide and laboratory purposes, or the small furnaces now coming into use in this country for heat-

treatment purposes. He thinks, however, that some day we may have large resistance furnaces suitable for heating guns, turbine and engine shafts, etc. One of the great difficulties experienced with large furnaces is due, he understands, to thermal expansion and contraction of the parts, and to the cost of repairing and replacing the heating units. But he believes these have been or are being overcome, and we should then have furnaces which would give uniform heating throughout the charge and with little scaling. Comparing our total of 117 electric steel furnaces with those installed in the United States and Canada, the author notes from "The Iron Age" that America in January, 1919, is credited with 287, which includes three induction furnaces (there are none in operation here so far as the author knows) and Canada is credited with 43 furnaces.

In conclusion the author hopes that when all our furnaces are in full swing again, their output efficiency may be at least as good, over a period, as those shown under "best month's output" for each type of furnace. In other words, that the 19 per cent. difference between the two may, if not actually disappear altogether, at any rate be materially reduced.

The Booth-Hall Electric Furnace.

By W. K. Booth.

The principal difference between the various makes of electric furnaces is the method in which the power is introduced in the furnace. The general metallurgical operations of practically all electric arc furnaces are the same. The method of power regulation and bringing the power to the furnace frequently means greater or less cost in furnace operation and governs, to a considerable extent, the manner in which the furnace lining may be put in and consequently the refractory cost, and the loss of time due to furnace shut-downs.

Electric arc furnaces may be broadly divided into two classes:—(1) Vertical arc furnaces with (a) conducting hearth, (b) non-conducting hearth; (2) horizontal arc furnaces. It is not the purpose here to enter into a discussion of the merits of the various types of arc furnaces, but more particularly to describe a new type of electric furnace which has been developed during the last year and which is known as the Booth-Hall electric furnace.

The Booth-Hall electric furnace comes under class 1 (a) above, and is illustrated diagrammatically in Figs. 1 to 4.

Fig. 1 is a longitudinal section of the two-phase electric furnace with arcs drawn between the main electrodes and the charge. A pool of metal is shown forming on the hearth of the furnace.

Fig. 2 is a diagram of a transverse section of the two-phase electric furnace, showing the crossing action of the current in the bath and the grids embedded in the hearth.

Fig. 3 is a diagrammatic representation of the electrical connections for the two-phase electric furnace employing two single-phase Scott-connected transformers. This diagram shows the connections from the transformer terminals to the main electrodes and to the auxiliary electrode and grids. A two-phase electric furnace so connected gives a balanced load on a three-phase power service. The auxiliary electrode is shown in black.

Fig. 4 shows diagrammatically the arrangement of main and auxiliary electrodes in single-, two-, and three-phase Booth-Hall furnaces. The auxiliary electrode is shown in black in each case.

The furnace is built either single-, two-, or three-phase to suit the conditions at the place of installation, the general principle being a furnace having a solid hearth which becomes conductive of electricity when hot, and the use of an auxiliary electrode which acts as a return for the electric current until the hearth becomes heated and conductive.

In starting furnace operations on a cold charge the auxiliary electrode is lowered until it rests on top of the charge, and the arc is then drawn between the charge and the main electrodes or electrode, as the case may be, the auxiliary acting as a return for the main electrode or electrodes. The auxiliary is so arranged that it presses with its entire weight on top of the charge and consequently no arc can form underneath the auxiliary; experience has demonstrated that no arc does form. The auxiliary is connected in parallel with the conducting hearth, and when the main electrodes or electrode have melted enough metal to form a pool on the bottom, the hearth becomes conductive and the auxiliary is withdrawn from contact with the charge. In a cold furnace the auxiliary is

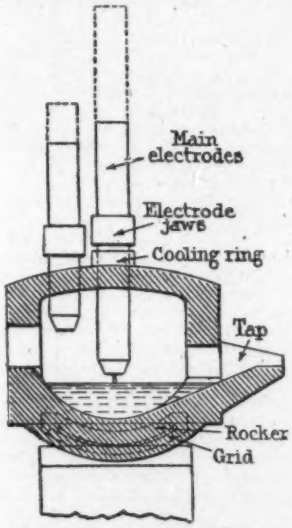


Fig. 1.—Longitudinal Section.

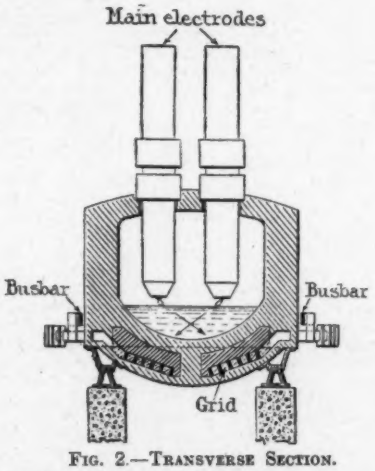


Fig. 2.—Transverse Section.

Fig. 4. — Diagrammatic Representation of Electrode Arrangement.

Booth-Hall Two-Phase Furnace.

in operation from 30 to 45 minutes, and, in a furnace which is hot, less than 15 minutes; that is, only long enough to assure a positive start of the furnace and a balanced load on the power company's line.

Furnaces from ½ ton to 6 tons holding capacity are generally built for two-phase operation, taking power from three-phase service by means of Scott-connected transformers, as shown diagrammatically in Fig. 3. In the hearth of the Booth-Hall two-phase electric furnace two sets of grids are embedded, which are electrically insulated from each other and are so related to the main electrodes that the current of the two phases cross in the bath, thus giving a maximum of circulation of the molten metal and causing, in conjunction with the effect of the bottom heating, a very thorough mixing of the metal in the bath. This action can readily be observed on looking into the furnace after the charge has entirely melted. The conducting grids are placed as far as possible from the heated interior of the furnace, and experience has shown that they never become overheated or require special cooling. The grids are so constructed as to handle large currents, furnishing large areas of contact with the material of the conducting bottom, and preventing local heating due to contact resistance.

By the use of the auxiliary electrode a positive start of the furnace is guaranteed, and there is no possibility of failure to secure contact. Each main electrode is independent of the other, as there are no arcs in series, and consequently the regulation of the furnace is very simple, giving a balanced polyphase load on the power service lines. As with the two-phase connection there are only two electrodes to regulate, this offers the minimum number of electrodes for a balanced polyphase load, and the smaller the number of electrodes requiring regulation the smoother becomes the furnace operation.

The hearth is either acid or basic, as desired, and in each case is at least 24 in. (60 cm.) in thickness, being sintered in place layer by layer and forming a monolithic mass. By using the main electrodes in conjunction with the auxiliary, the materials of the hearth are sintered together in thin layers similar to open-hearth practice, thus forming a very durable bottom, and making the danger of run-outs a minimum. The furnace hearth is consequently solid, with no water cooling of any kind. With the basic hearth, dead burned dolomite is used to maintain the slag line; in the acid furnace, ground ganister is used for the same purpose. The conducting hearth gives a uniform bottom, and making the danger of run-outs a minimum, makes speedier and more thorough distribution of the heavier alloys, which tend to sink to the bottom of the bath. The effect of this bottom heating is considerable, and has been accurately measured on Booth-Hall furnaces in continuous operation.

With the two-phase electric furnace a minimum of electrode consumption is secured, due to the fact that a minimum number of electrodes for a balanced polyphase load is used. This means fewer electrodes to handle, less electrode breakage, and less surface burning. The loss on the auxiliary electrode is small, because it is in operation for such a comparatively short time. The electrode jaws are made so that the electrodes can be gripped or released by turning a handwheel or lever at the side of the furnace, and it is not therefore necessary for the melter to climb on top of his furnace when changing the grip on the electrodes. The electric jaws are arranged in segments so as to take up and adjust themselves to the inaccuracies in the surface of the electrodes.

A roomy charging door of special construction is provided in the rear of the furnace, and another door in front over the tap. This construction is very similar to the open-hearth, and permits a battery of furnaces to be arranged side by side and a charging machine to serve them all. The furnace tilts or rocks backward as well as forward, and slagging operations can be handled from either the rear or the front as desired. The door is designed so that it comes flush against the door frame, sealing the opening, and cannot swing open of its own accord. This prevents air getting into the furnace, and also prevents excessive losses of heat through the door. The door can be opened anywhere from a few inches to full open when inspecting the bath, taking tests, or pushing scrap from the sides of the furnace into the bath, thus protecting the melter from the heat of the furnace and preventing great radiation loss. Any warping of the door or frame does not affect the operation of the door or its sealing of the opening when closed.

The furnace is motor-tilted in all sizes for pouring, but is arranged so that it can be tilted by hand in emergency if the motor fails to operate. The smaller sizes of furnace are built for hand operation only, if desired. All parts of the tilting mechanism, including gears and motors, are arranged so that they do not come beneath the furnace that can be injured in case of a run-out.

The main electrodes are arranged for automatic regulation and also, in every case, so that they can be regulated by hand in case the regulators or motors should require repair.

The importance of power control is universally recognised, especially when refining operations are carried on. In the Booth-Hall electric furnace the power input can be maintained at any point from one-

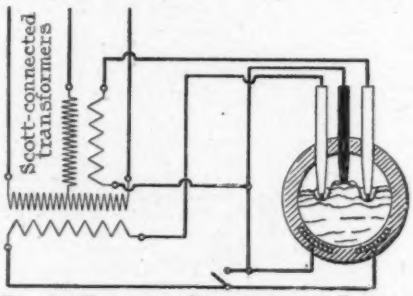


FIG. 3.—ELECTRICAL CONNECTIONS OF BOOTH-HALL TWO-PHASE FURNACE.

fourth to full load by means of proper voltage reduction and control switches.

In making steel for the ordinary grade of steel castings, the Booth-Hall electric furnace has operated with a power consumption as low as 446 kw.-hours per 2,000 lbs. (906 kg.) of steel poured, but the average will be between 500 and 550 kw.-hours per net ton for continuous operation. In one of the 4-ton furnaces a considerable quantity of low-phosphorus pig-iron has been made, running over 0.035 per cent. in phosphorus and sulphur, also special steels requiring refining with two or more slags, the power consumption, of course, depending upon the degree of refining required.

A New Type of Electric Furnace.

BY AXEL SAHLIN.

The electric furnaces hitherto constructed may be divided into three different groups, viz.: (*a*) Induction furnaces; (*b*) Furnaces with a free-burning arc; and (*c*) Furnaces relying on a direct arc between the metal and the bath. The first-mentioned type of furnace is now only occasionally found. The free-burning arc furnaces have found favour, especially for work where it is desirable to avoid any chemical reaction between the carbon in the electrodes and the bath. They have a decided advantage in giving the means of heating the cold furnace without the introduction of any charge and by the arc only. On the other hand, they have

the disadvantage that, as soon as the bath is formed, the heat is transmitted to the surface only and no circulation is set up in the molten metal. Many furnaces of this type have suffered from defective and weak mechanical construction. On that ground some users have preferred direct arc furnaces, in spite of the disadvantages of heavy and cumbersome electrodes, furnace roofs pierced by large holes, and the necessity of using a source of heat other than the electric current to bring the furnace up to melting temperature.

The furnace which is the subject of this Paper has been designed with a view to embodying the advantages of both the direct arc and the free-burning arc furnaces, at the same time avoiding as far as possible the disadvantages of both.

Description.—The furnace is built as a circular ladle with contracted top and dished bottom. The shell is made of heavy steel plates, riveted together with ¾-in. rivets closely spaced. The plates are perforated by ¾-in. drilled holes, spaced about 12 in. apart and serving as vents for moisture contained in the lining. The top rim is reinforced by a heavy flat hoop riveted to the shell plates. The steel casting trunnions are riveted to the shell and rest in bearings set so as to allow for expansion and alignment. To the overhanging end of one trunnion is keyed a crank which, by means of an enclosed screw, running in oil, working in a swivelled crosshead and turned by hand-wheel (or, for larger furnaces, by motor) serves to tilt the furnace to any desired angle.

The bottom of the furnace is made up of a layer of coke dust and tar rammed in, supporting double layers of brick. On top of this is rammed and fixed in successive layers a hearth consisting of burnt dolomite and tar for basic operation, or of ganister in case the acid process is adopted. Supported and resting on the firebrick, outside the hearth, is placed a circular lining backed by a heavy insulating layer of asbestos sheet and formed of circle-bricks laid with ground joints and thin mortar. This lining may be made of magnesite brick for basic process, or of silica brick for acid process. In the lining are placed on the same vertical lines two holes for each pair of electrodes, and one door opening which serves both to charge the furnace and to pour the steel. For larger furnaces one tapping hole and two charging doors would be a better arrangement.

On top of the contracted top of the side lining rests the dome-shaped roof built of basic or acid brick fitted in a circular steel frame, forming a rigid skewback. The roof joint is made of a layer of powdered dolomite or ganister spread on top of the side wall. The roof can be removed by crane without delay, and replaced by another preheated roof held in readiness to take its place. As it is found that the portion of the roof opposite to the arcs is affected more readily than the portion nearest to the electrodes (which is protected to a certain extent by the shadow of the latter) the roof can be turned round to any angle desired. Thus, when the weakest portion is getting thin, the life of the roof can be prolonged by exposing to the fiercest heat the section of the roof hitherto more protected. It is also possible to charge the furnace through the top by removing the roof while the charge is put in place.

Electrodes.—The electrodes are graphite or carbon electrodes, of cylindrical form, extended as they are burnt away by screwing a new section of electrode to the rear end of the electrode in operation. The joint is made by threaded dowels of graphite. The electrodes slide through water-cooled electrode holders made of steel pipes welded to rings at the front and back ends. Nozzles for water supply and discharge are tapped into these rings, and are connected with rubber hose to the water mains. The electrodes are wrapped in sheets of asbestos, mica, or fibre, and are thus insulated from the furnace body.

The electrode cooler with its insulation is placed between the fixed upper and sliding lower jaws of a clamp which is pivoted to a frame bolted to the furnace shell. A wedge placed beneath the lower jaw of the clamp causes it to grip and firmly hold the insulated cooler with the electrode sliding through the same.

The top part of the clamp is extended outward, forming a support and U-shaped guide for the slide which grips the rear portion of the electrode. In the hollow interior of the U-shaped guide works a screw which engages against a nut held in place by prongs extending from the electrode holder. If the screw is turned, the electrode holder is moved toward or away from the furnace, advancing or retiring the electrode. The upper portion of the electrode holder is insulated from the grip by a sheet of fibre. The lower swivelling portion of the grip is closed and tightened by an eye bolt with hand-wheel nut. Both halves of the grips are water-cooled, and are fed through nipples connected to the water mains by rubber hose. Both grips are made with an extending wing, to which is bolted the bronze cable socket which receives the end of the cables, transmitting the current from the switchboard to the electrode. Both the swivelled guides are adjusted in a vertical sense, controlling at will the inclination of the electrodes.

Electric Arrangement and Wiring.—The number of electrodes proposed is as follows:—For a furnace hearth, up to 3 ft. 6 in. diameter, 1 pair; from 3 ft. 6 in to 5 ft. diameter, 2 pairs; from 5 ft. to 7 ft.

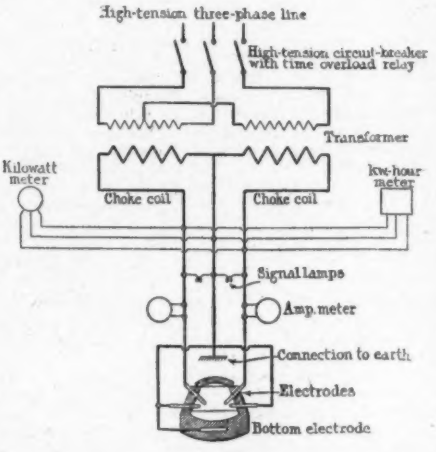


FIG. 1.

diameter, 3 pairs; from 7 ft. to 9 ft. diameter, 4 pairs; from 9 ft. to 11 ft. diameter, 6 pairs. This number can be modified according to circumstances.

The electrodes should be preferably of graphite, varying from 2 in. up to 6 in. diameter, according to the size of the furnace and the amount of current. Each pair of electrodes enters the furnace in the same vertical plane, but at different and adjustable angles. The upper electrodes are supplied with current. The lower electrodes, as well as the furnace body (and, if the furnace is going to be used largely for refining work, a bottom electrode bedded in the hearth), are connected with the common of the transformer, or earthed. For a one-pair furnace, direct current or one-phase alternating current is used. For a two-pair furnace it is preferable to employ two-phase current, generally obtained by three-phase transformers arranged in Scott's coupling. For a three-pair furnace, three-phase current is used, one phase being coupled to each upper electrode. For furnaces with more than three pairs of electrodes, groups of two pairs are coupled in parallel; therefore, a four-pair electrode furnace uses two-phase current, whereas a six-pair furnace should be supplied with three-phase current. If for any reason it may be found desirable, the upper electrodes can be earthed, and the current can be supplied

through the lower electrodes. A bottom electrode buried in the hearth may be used or not. It is useful when refining, because, as the lining material gets very hot, this becomes a good conductor and passes the current through the bath into the bottom electrode when using the direct arc. The pressure of the supply should preferably be transformed to 100 volts, which, by plugs on the transformer, may be reduced at option to 80 or 70 volts.

The connections for a two-pair furnace are shown in Fig. 1. To avoid any chance of shock to operators, it is advisable to place a wooden operating platform over the floor at the back of the furnace around the electrodes. All the electrodes are distributed around the half of the circumference of the furnace opposite to the tapping hole and charging doors. For the smaller sizes of furnaces, the electrodes are fed forward by hand-wheels. The current taken is observed by reading kilowatt meters placed on a switchboard suitably located, and receiving the feeders from the transformers. It seems to be an advantage to provide choke coils to steady the current.

Operation.—Assuming that the furnace is to be used for melting and refining steel, the first operation is the heating of the furnace to the proper temperature. This is effected by turning on current and gradually advancing the points of the convergent electrodes of each pair until an arc is formed. Experiments have proved that as long as the points of the electrodes are at a certain distance from each other an arc is formed between the two electrodes. As the electrodes approach each other this arc bends outward, forming a loop. If the distance is still further reduced, the loop breaks and the arc rushes forward, sweeping downward toward the surface of the metal like a broom. If the top electrode is advanced beyond the bottom electrode, the broom is deflected downward (see Fig. 2). The form

FIG. 2.

and direction of the arc can easily be modified by altering the angles of the electrodes and their relative position to each other. The free-burning arc heats the furnace while empty.

The second operation would be the charging. When the furnace is heated, current is taken off, and the electrodes are drawn toward the back wall of the furnace to prevent their being injured, while the material to be melted is thrown or pushed into the furnace through the charging door, and eventually through the furnace top, the roof having been removed. As soon as the charge has been placed in the furnace, the electrodes are advanced. Experience has shown that numerous momentary arcs are formed between the upper electrodes and the charge, but as this latter is melted away in the vicinity of the electrodes, the regular free-burning "broom" arc is formed between the two electrodes and the working of the furnace settles down to normal. The radiation and reflection caused by the free-burning arc are most effective for rapid melting. As, however, the bath is formed, this kind of arc reaches only the slag-covered surface of the metal, causing but little circulation in the interior of the bath. At this point, therefore, the free-burning arcs are broken by the retirement of the lower electrodes and a direct arc is formed by the advancing of the upper inclined electrodes toward the surface of the slag. If the bottom electrode is employed, the current will penetrate toward the bottom electrode which is earthed. The furnace is now working on the lines of a Girod furnace, and creates an electric arc which causes a rapid circulation in the bath and direct transfer of heat to the metal.

In furnaces with more than one pair of electrodes, it is possible to have some of the electrodes produce a direct, and some a free-burning, arc, thus making use of the effective radiating and reflecting action of the free-burning arc, at the same time as the bath is agitated by the direct arcs.

Special Work.—For use as a heating furnace for very high temperatures, such as are required for the production of graphite, for the calcining of magnesite, for the crystallising of bauxite, for special crucible work, and for other similar objects, it is proposed to suspend the furnace shell containing the side walls and roof with the electrodes and the electrode mechanism from four lifting rods, operated by electric motor, hydraulic cylinder, or windlass. The bottom of the furnace, which for this work does not require any bottom electrode, would be placed on a truck. On this portable bottom would be placed, in proper arrangement, the material to be heated. The loaded truck being placed beneath the furnace body, this would be lowered on to the truck enclosing the pile of material. A free-burning arc would now be started between the electrodes in each pair, and the furnace would be brought up to the required temperature. The material having been thoroughly heated or calcined, the furnace body would be lifted from the truck, which would be run away to give place to a second truck loaded with fresh material. The loaded trucks could be pre-heated in a gas-fired furnace before the bottom was placed under the electric furnace. This procedure has been described only as an indication of a use for the electric furnace, filling a long-felt want, but the actual arrangement of the plant would, no doubt, be different for each case, and should be separately studied.

Advantages.—It will be found that the furnace, as above described, is of a very strong construction—rigid, simple, and durable. All the surfaces of the brick linings are convex, and the walls will therefore be held in position. The surface of the melting room, confined by spherical and cylindrical walls, is the smallest possible for the largest volume, and the amount of brickwork in the furnace is therefore reduced to a minimum. The electrodes are easily secured in place, adjusted, advanced, or retracted by means of hand-wheels. There are no bolts or nuts manipulated by wrenches used in the adjustment of the furnace, every operation being carried out by hand-wheels or cotters. The roof is solid, without any openings, removable and exchangeable in a minimum space of time. The furnace can be run either with free-burning arcs, with direct arcs, or with free-burning and direct arcs working simultaneously side by side. Changes are made without cutting off the current.

When the furnace is employed as a free-burning arc furnace no chemical reaction between carbon of the electrodes and the bath takes place. The overhanging length of the electrodes is comparatively short, and the arcs are formed fairly close to the circular furnace walls, being directed inward and downward toward the centre of the furnace.

The Sahlin furnace has not yet been placed on the market, owing to the difficulty of obtaining a permit for its construction during the war, but a furnace is now being built in Great Britain intended for the production of steel ingots and castings.

Large Electric Steel-Melting Furnaces.

BY VICTOR STOBIE.

The author's commercial and technical experience with small and large electric-arc steel-smelting furnaces has led him to favour the latter for ingot making on account of the more advantageous costs and conditions of working of large units. The smaller furnaces have a very large field in foundry work. Observations will be confined mainly to the technical requirements of large plant and to some interesting phenomena on all furnaces.

Wiring Diagrams and Shapes of Furnaces.—The wiring diagrams (Figs. 1, 2, and 3) give what the

author considers to be the best connections for three sizes of furnaces.

Fig. 1 is for furnaces up to 6 tons capacity : two-phase current, each phase maintained entirely separate from the other, with one end of each phase connected to separate electrodes above the bath and the other end of each phase connected to separate electrodes embedded in the hearth of the furnace at opposite ends of the furnace to their relative top electrodes. This arrangement gives exactly the requisite bottom heating for small furnaces, and is characterised by the crossing of the currents in the direction of flow through the bath.

Fig 2 is for furnaces from 6 tons up to 24 tons capacity : two-phase current, each phase maintained entirely separate from the other, with each end of

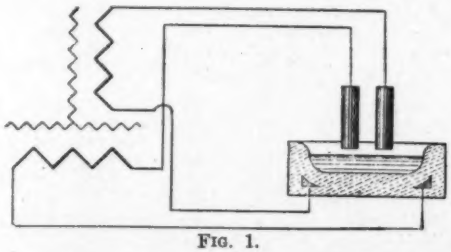


FIG. 1.

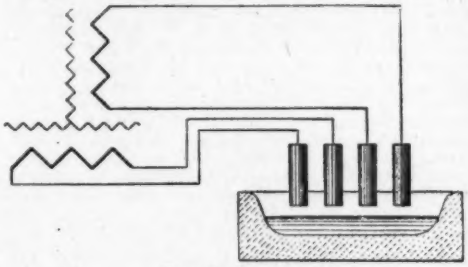


FIG. 2.

each phase terminating in an electrode above the bath. Long experience has shown that bottom electrodes, whilst essential in small furnaces, are very undesirable in large furnaces.

Fig. 3 is for furnaces above 24 tons capacity : three-phase current, each phase maintained entirely separate from the others, with each end of each phase terminating in an electrode above the bath.

The most favourable shapes for tilting electric furnaces would appear to be :—Up to 6 tons : Rectangular in plan and in elevation with a curved bottom. From 7 to 24 tons : Octagonal in plan.

travels irregularly round and under the lower extremity of the electrode, and is seldom at more than one point of the electrode at a time. The arc proper is the source but not the only point of heating of the furnace charge. A flame of carbonaceous gas, measuring in large furnaces as much as 2 ft. long, travels over the bath from each electrode. This flame is quite the hottest flame in commercial use and has great influence on the distribution of heat in the furnace. It is this flame which, by immediately travelling upwards in some designs of furnaces, causes therein excessively quick burning away of the roof and door arches. It will rapidly flux the banks of the furnace if allowed to impinge thereon.

Experiments were made at the Stobie Steelworks at Dunston-on-Tyne, near Newcastle, to obtain data as to the cause and effect of the direction of travel of the flame from the electrode. Some control was obtained over the direction of the flame by alterations in the direction of rotation of the magnetic field of the supply currents. A certain change of direction of the flame resulted also from varying the phase reaching each electrode. The extent of the control over the flame was sufficient to make a decided change in the speed of working of a furnace and in the wear and tear of the lining. Unfortunately, no definite rule for guidance can be laid down at present, as the matter further depends upon the position of the flames

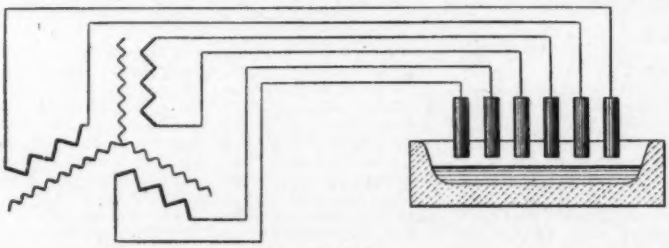


FIG. 3.

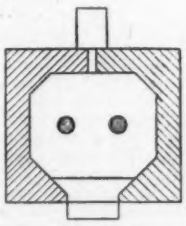


FIG. 4.

Above 24 tons : Octagonal with lengthened back and front walls. Stationary furnaces should always be rectangular.

The above shapes ensure the most convenient position for the electrodes in the furnace and help to keep the furnace walls at the average greatest distance from the electrodes, as illustrated in Figs. 4 to 6. It is most essential that electrodes should be in the positions shown and not opposite to doors, in order to avoid the breaking of electrodes when material is thrown into the furnaces. A 5-ton Stobie electric steel-melting furnace is shown in Fig. 7.

Arc Phenomena.—The arc phenomena in a steel-melting electric furnace are very important and interesting. The arc proper jumps between the bath and whichever portion of the electrode is nearest to the bath. As this point is always changing, the arc in relation to each other, and, possibly, the magnetic fields external to the melting chamber.

Experiments on the blowing of the arc flames in furnaces by strong external continuous magnetic fields were then made in order to eliminate the uncertainty of coincidence of the revolving magnetic fields with some of the arcs in the polyphase systems of electric furnaces. Powerful lifting electro-magnets were used for this purpose. Again, the many other factors existing within the arcing zones prevented any definite rule from being framed; but by a careful disposition of the electrodes and cables in an installation so as to cause the magnetic fields coincident with certain arcs to blow the arcs in a desired direction, a most important increase in speed of melting and reduction in wear and tear of furnace lining are undoubtedly obtained.

In some types of electric furnaces arcs are maintained between adjacent electrodes and not between electrodes and bath. In such furnaces the property of inter-repulsion of arc flames is utilised in order to fan the flames over the material to be melted, whilst much of the heat energy in the circuit, viz., that in the arcs proper, travels only between the electrodes. This is the cause of the current consumed per ton of steel melted being high in such furnaces.

It was once believed that the great heat (*circa* 3,600 deg. C.) of the arcs in an electric furnace would have a detrimental effect on the steel. More recent experience teaches us that, so long as a steel is thoroughly deoxidised before casting, only the temperature of casting is of moment.

Transformers.—One might, with reason, say that the heart of the electrical equipment of an electric furnace installation is the transforming apparatus. Either through poor construction or short capacity a considerable number of transformers attached to early furnaces gave trouble. The stresses which the transformers have to resist are of an exceedingly heavy order. The plant has to withstand occasional short-circuiting through the furnace and, perhaps once or more in its life, the equivalent of almost a dead short-circuit. It has to allow frequent breaking of the circuits under heavy overload and, should the furnace hands be careless and the plant be unprovided with proper protective devices, of occasional switching direct on to overload.

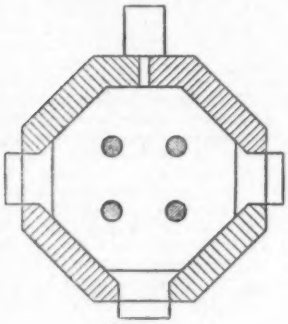


FIG. 5.

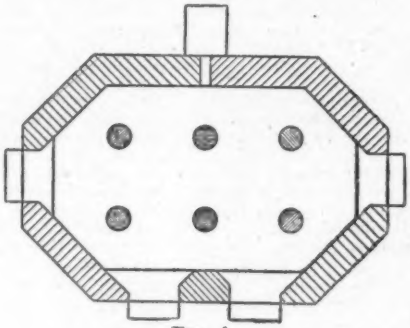


FIG. 6.

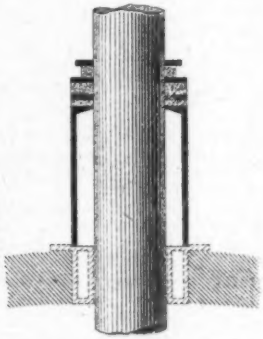


FIG. 9.—STOBIE ELECTRODE ECONOMISER.

The requirements in the design of the transformers are :—(1) That the current density of both the low-tension and extra-high-tension windings shall be low enough to prevent the inevitable overloads from unduly heating up and deteriorating the insulation. (2) The ventilating channels in the windings must be specially well considered so as to provide low resistance paths for the cooling oil without excessive magnetic leakage. (3) That windings shall be braced on all sides. (4) The low-tension windings shall be taped with such material as empire tape, in addition to press-spahn or similar stiff insulation. (5) All clamps, no matter how small they may be, should be anchored to the transformer frame work. (6) The whole of the apparatus must be as unyielding to magnetic stresses as mechanical skill can make it. (7) As much as possible of the total reactance required in the whole of the furnace installation should be incorporated in the transformers.

A very few years ago furnace transformers were built upon very different lines from the above. In the year 1915 the author first specified the taping of the low-tension winding of furnace transformers and the anchoring of all clamps, the reason for these requests being that several transformers had broken down through the meeting of two lengths of low-tension copper above the windings, and that the shrinkage of wood composing parts of clamps allowed several clamps to fall and the tightening bolts had narrowly escaped short-circuiting the low-tension windings. The above practice has now become general for furnace transformers.

As a result of observations of the breakdown of some furnace transformers, the bracing of all sides of the windings of transformers was specified by the author in 1917, and a shell type of transformer embodying that feature was designed in collaboration with a well-known transformer firm. The design has now been standardised also for large power transformers.

It is usual to have several tappings brought out from the high-tension windings of furnace transformers, as the voltage required on a furnace during melting is always higher than when finishing a heat. All such tappings should be brought away from the central portions of the winding, the complete high-tension winding being divided into two at the mid-point and the tappings bridged across the mid-point to cut out equal portions of each half of the windings when required. By taking the tappings out in this way, the insulation of the end turns of the high-tension windings can be suitably reinforced to withstand any abnormal voltage stress on switching in the transformers.

On the practical side, useful results have been obtained at the Stobie Steelworks by limiting the current density in transformer windings to 1,250 amperes per sq. in., the induction in the iron to about 12,000 C.G.S. lines, and the temperature rise on continuous full-load to 45 deg. C., measured by the increase in resistance. In addition to pressure-testing at twice the working voltage, an over-potential test at this double voltage is made on the high-tension side, the periodicity being increased to keep down the magnetising current. The low-tension windings of large furnace transformers should be tested at a potential several times greater than normal by being connected in series, the low-tension coils almost invariably being designed for parallel working.

Automatic Electrode Regulators.—A few observations on automatic electrode regulators from the furnace user's point of view may be useful. The desiderata in automatic regulation mechanism include sensitiveness without fragility, and simply setting to limits. If the furnace circuits contain two arcs in series, it is necessary that the energy in each of such two arcs should be balanced, whatever current is flowing. This is accomplished in Stobie electric furnaces by operating one electrode motor by an automatic current controller and the other by an automatic potential controller. The current controller is adjusted to give the limits of current required and will keep its electrode at any position at which such desired current will flow. The potential controller is adjusted so that half the phase voltage, *i.e.*, the normal voltage between one electrode and the furnace charge, is maintained on the electrode it controls. The result is that

the potential-regulating motor will keep its electrode at the same distance from the molten steel as the current-regulating motor keeps the other electrode, as at that distance the current will be normal and the voltage balanced.

On some electric furnaces which the author is building for other steelworks the balancing of two arcs in series is automatically controlled in a different manner. The current regulator is connected to one electrode as in the previous system, whilst the potential regulator connected to the other electrode is operated as follows :—A shunt from each electrode to the bath is passed through separate solenoids placed side by side. An armature in the shape of a bar suspended by the middle hangs over the two solenoids. When the pull of one solenoid exceeds that of the other, one end of the bar is pulled down on to contacts which operate, through contactor switches, the electrode motor in one direction. When the voltage is greater on the other solenoid, the other end of the lever is pulled down by that solenoid and the electrode motor is operated in the opposite direction.

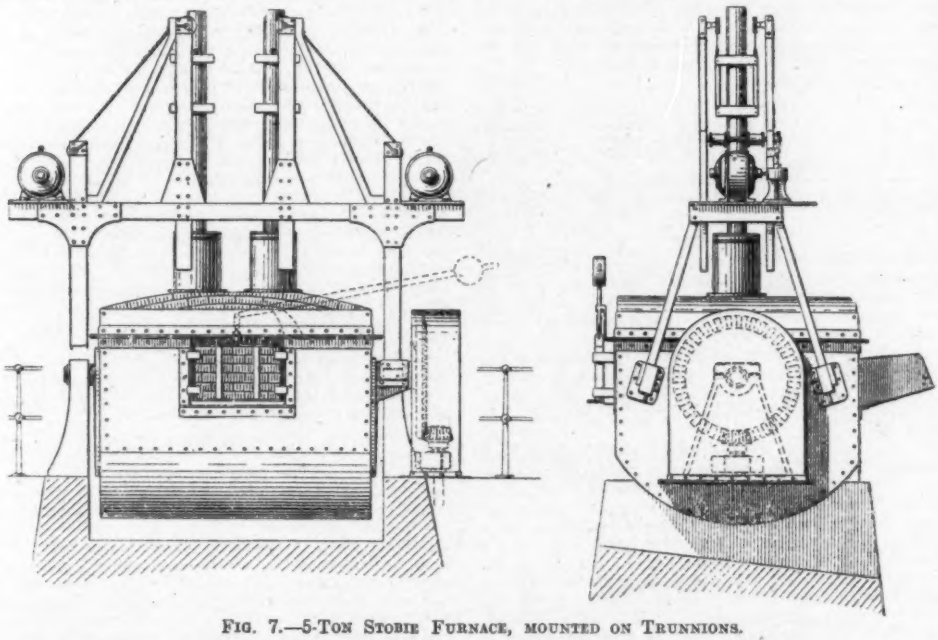


FIG. 7.—5-TON STOBIE FURNACE, MOUNTED ON TRUNNIONS.

Power Factor.—The power factor of an electric furnace installation depends upon the circuit reactances and the power factor of the arc. The power factor of alternating arcs varies from almost unity to lower than 0.7 in the case of arcs between cold hard metals. In electric furnaces the power factor of the arcs will vary with the steadiness of the arcs and the materials forming the arcing points. As is known, the apparent resistance of an arc varies with the current passing through it, being high for a low current. The voltage wave consequently is distorted and forms a sharp peak at the commencement and end of each half-cycle, with a strongly marked depression between. The current wave approximately retains its sine shape, and a lagging power factor results without any phase displacement.

The circuit reactances are divided between the transformers and the leads. Due to the large sizes of conductors used, and to the large area enclosed by the circuits, reactance in furnace work has a tendency to be very high, unless strictly controlled. At the same time, very low reactance would be undesirable on large power systems in view of the frequent short-circuits through the furnace. The total impedance on short-circuiting through a cold charge in a furnace depends very much on the type and condition of the scrap being melted, and will usually be quite high enough to reduce all shocks to reasonable limits. If, however, a short-circuit takes place through a molten steel bath, the impedance will be relatively low on account of the good conductivity of the bath, unless a reasonable amount of reactance is incorporated in the circuits. Such short-circuits are, fortunately, very rare in well-designed furnaces.

The total impedance at the moment of starting a large furnace with poor scrap sometimes reaches over 90 per cent. With average scrap it ranges between 40 and 60 per cent. When melting armour scrap or other clean heavy material it little exceeds the reactance.

A 15-ton Stobie furnace gives the following power factors :—On melting, 0.84; when charge is half melted, 0.85; when charge is almost melted, 0.87; when charge is melted, 0.93. The average (in relation to the magnitude of the load) power factor over the total of units consumed at the Stobie Steel Company's works, including all motors for fitting shop, cranes, furnace auxiliaries and the furnaces themselves, varies between 0.86 and 0.88. The furnace load is about 90 per cent. of the total load, and the balance is taken by intermittent lightly-loaded low-power-factor motor circuits. It can therefore be safely stated that large furnaces such as the 10-ton, 15-ton, and 20-ton Stobie furnaces give an average power factor of fully 0.88 over all units consumed.

The author has heard it stated at various times that one or other particular design of furnace can be worked safely at almost unity power factor. Sooner or later one hears of the collapse of some part of such gear due almost certainly to serious current surges. Considerable experience in the designing and operating of electric furnaces teaches one to aim for safety before unnecessarily high electrical performance, and this rules out of consideration furnace installations with less than 20 per cent. impedance voltage when short-circuited across the electrode terminals. The author

aims at installing plant in such a manner that on dead short-circuit the power factor is momentarily reduced to 0.4 or even 0.3. This need not mitigate against the excellent normal power factors already mentioned.

Electrode Considerations.—The presence of electrodes in electric arc furnaces is, for the user and designer, an unfortunate necessity. The function of the electrodes is to conduct the current into the furnace and to produce an arc gap in each electrical circuit, in order to localise, as far as possible, the conversion of the current into heat at the requisite points in the furnace. The desirable characteristics of an electrode are: low resistivity, relative incombustibility, and cheapness. No material combines these qualities. The nearest approach is found in carbon, and one has the choice between amorphous and graphitic carbon electrodes. The resistivity of the amorphous variety is, roughly, four times that of the graphitic. This enables graphitic electrodes to be made of smaller diameter than amorphous ones for equal current-carrying capacity. The following table gives the comparative data of both types of electrodes, including the diameter of electrode sufficient to carry, in practice, 10,000 amperes safely:—

	Specific resistance per cm. cube.	Lowest temperature of combustion.	Diameter to carry 10,000 amperes.
Amorphous electrode ..	0.00332 ohm	513 deg. C.	12 in.
Graphite electrode ..	0.00114 ,,	624 deg. C.	20 in.

Graphite electrodes have not, in the author's opinion, progressed among electric furnace users so well as they would have done had unsupportable claims not been made in their favour. This is a matter which would not concern this Paper but for a very important point, almost invariably overlooked by designers and users of electric furnaces, which should be ever in mind when considering the engineering features of large electric furnace installations. This point is "skin effect."

The early users of graphitic electrodes obtained their experience on non-ferrous furnaces using direct current. When the electrodes were introduced into steel-melting furnaces, which were all supplied with alternating current, it was found that the electrodes were much too hot at current densities far below the maker's recommendations. The average current density in the main current-carrying area of an electrode in an alternating-current steel furnace being roughly twice the average current density of the whole area, due to skin effect, the electrode will not usefully carry as heavy a total current as is generally claimed. This same phenomenon will attain considerable importance in other parts of large furnace plant and lead to great loss of energy and materials, unless studied in detail.

The main consumption of the electrodes in ordinary electric steel furnaces does not take place at the arcing end of the electrodes, but results from the surface burning of the carbon all over those parts of the electrodes which are inside the melting chamber and up to a point about 15 inches above the roof. On looking inside most furnaces the electrodes will be seen to be considerably tapered from where they enter the roof down to the arcing ends. Fully 75 per cent. of the heavy expenditure on electrodes is wasted through this defect. Various attempts to prevent this costly waste of electrodes have been previously made, such as (1) enveloping the carbons with asbestos paste held in position by wire netting; (2) coating the electrodes with non-burning paints; (3) encircling the electrodes with steel collars held together by hinges or springs; (4) surrounding the electrodes with water-cooled cylinders extending well inside the furnace. All such methods have met with failure because, by the first method, the asbestos perishes quickly inside the melting chamber and is expensive to apply; in (2) the non-burning coatings all expand and fall away from the non-expanding carbon electrode; in (3) the collars do not protect red-hot electrodes from the air above the roof, the collars are not efficient in keeping back the flames, but have a very short life and are expensive in upkeep; and in (4) the internal jackets are most wasteful of heat and, further, are dangerous inside the furnace and very ineffective.

It is thought by some people not acquainted with electric furnace practice that there is always a reducing atmosphere inside electric furnaces of the older types in use. This is an utterly mistaken notion, which is proved by the ease with which the raw materials charged into such furnaces oxidise, even without the help of iron ore or other solid oxidant.

The cause of the oxidising atmosphere inside the older electric furnaces is the crude method of feeding the electrodes into the melting chamber. This is usually done by leaving in the roof a number of plain holes equal to the number of electrodes which have to be continuously fed into the furnace; the bricks forming such holes support annular water jackets which fit, with a small clearance, new electrodes. The heated gases inside the furnace continuously pass up those clearances between the roof and the electrodes. The results are manifold: it causes the clearance to be rapidly increased by the flames burning away the electrodes to a tapered point as previously explained; it wastes all the heat value of the gases and flames which are constantly pouring out of the furnace through the electrode holes; it lengthens the duration of a charge in proportion to the heat lost through the roof holes; the escaping flames cause the electrode gear and current conductors over the roof to deteriorate rapidly; and the undue heating of the electrode terminals necessitates their being water-cooled. The considerable effect of all this on the cost of producing the steel, quite apart from some loss of control therefrom over the operations of the furnace, will be readily apparent.

At first sight it may seem a simple matter to close up the clearance between the roof of a furnace and the electrodes passing through it; but the following will illustrate some of the difficulties.

It has often been attempted to make the water-coolers round the holes a sliding fit on the electrodes. To enable this to be done the electrode must be machined to size; a most expensive detail when amorphous electrodes are used. When the machined electrodes are placed in position, the parts which are inside the melting chamber become white hot. Every time an electrode is raised—a constant operation in electric steel melting—some white hot or bright red hot part of the electrode is raised into the air above the furnace roof and burns away at the surface to a small or great extent. Each such reduction in diameter of the electrode commences or increases the clearance between the water jacket and the electrode, thus only delaying for a few hours the state of affairs existing in furnaces which start with the usual large clearance round the electrode.

The difficulty has now been successfully overcome in a simple way. Observations showed that at about 2 ft. above the roof in most furnaces the electrodes, even when raised for charging, are seldom at a temperature at which they can burn; therefore, that is the only point at which a permanently good seal can be made round the electrodes. If an electrode is closed hermetically from the roof up to that point, the burning away of the electrode and the escaping of the heated gases from the furnace are prevented.

In practice, a light metal cylinder a few inches larger in diameter than the electrode and about 2 ft. in length is fixed on the roof round each electrode. The top end of the jacket is covered with a sealing plate which prevents the passage of the flames, the electrode passing through a neatly fitting hole in the centre of such cover. Fig. 8 illustrates the effect of the apparatus.

In this figure A shows a new electrode when first placed in an electric furnace.

B shows the effect when the electrode has been in use for a few hours. The surface inside the furnace is burnt away by the internal atmosphere and, as the ing a fresh charge. That part of the electrode where the surface has been burnt away inside the furnace has to be raised partly above the roof. This results

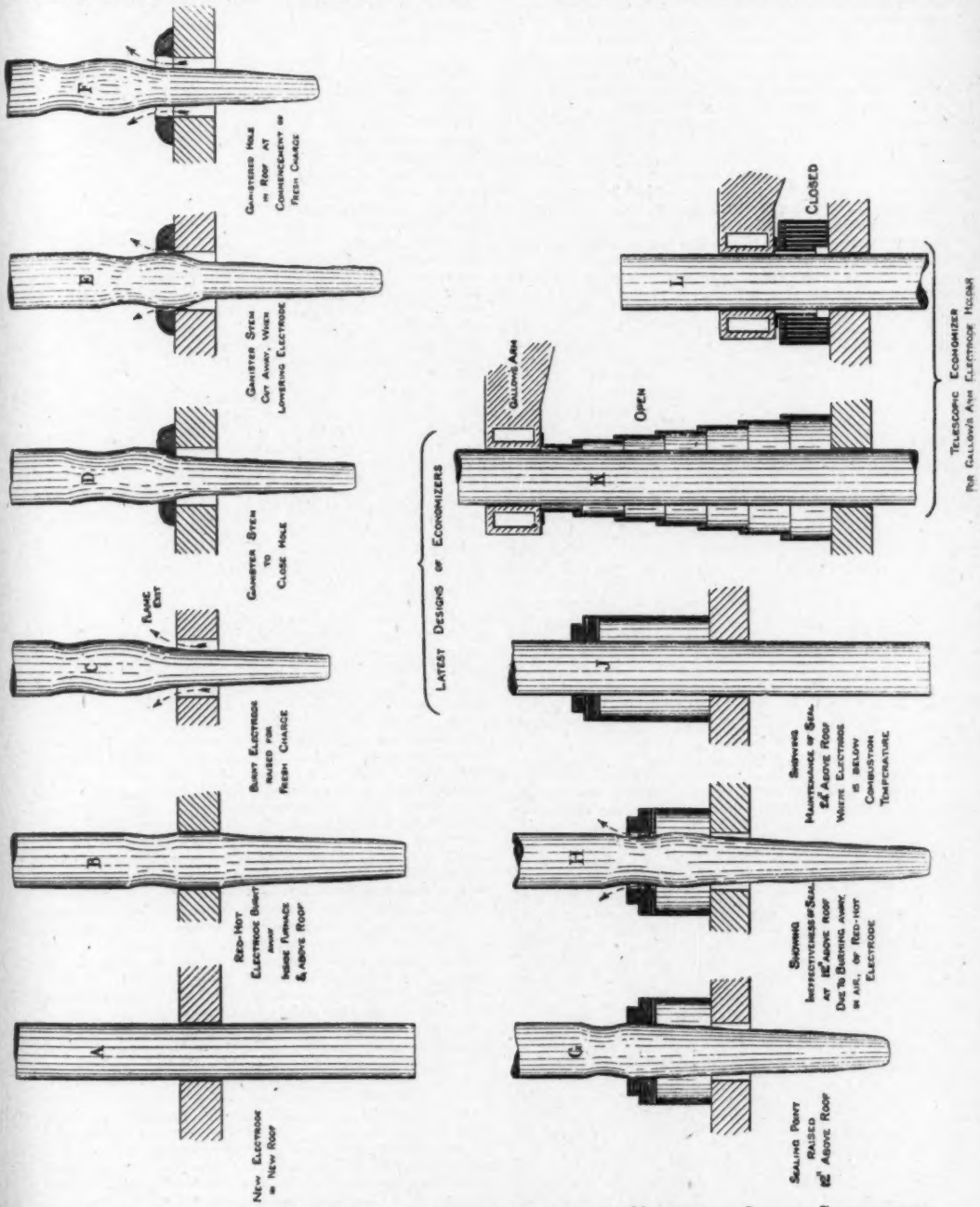

E
Gaugstered Hole in Roof at Commencement of Fresh Charge
E
Gaugster Stem Cut Away, When Lowering Electrode
D
Gaugster Stem to Close Hole
Flame Exit
C
Burnt Electrode Raised for Fresh Charge
B
Red-Hot Electrode Burnt away Inside Furnace & above Roof
A
New Electrode = New Roof
Latest Designs of Economizers
Closed
L
Open
Gallows Arm
K
Telescopic Economizer for Gallows Arm Electrode Holder
J
Showing Maintenance of Seal 12" Above Roof While Electrode is below Combustion Temperature
H
Showing Ineffectiveness of Seal at 18" above Roof Due to Burning away in Air, of Red-Hot Electrode
G
Sealing Point Raised 12" Above Roof

FIG. 8.—EFFECT OF STOBIE ECONOMISERS, COMPARED WITH ORDINARY METHODS OF SEALING CONTINUOUSLY-FED ELECTRODES IN ELECTRIC STEEL-MELTING FURNACES.

electrode is red hot above the roof, the electrode also burns away there in the free air.

C shows the effect of raising the electrode for melt- in an immediate extension of the clearance between the electrode and the electrode hole in the roof. The result is that the flames rush out of the furnace

through the roof and rapidly burn away the electrode.

D illustrates the usual way of sealing the electrodes. Ganister or similar material is thrown against the electrode to seal up the clearance in the electrode hole.

E shows how the ganister stem is cut away by the electrode when the latter is again lowered.

F shows the uselessness of the ganister stemming immediately the electrode is again raised, due to the thick part of the electrode having created almost as much clearance between the electrode and the ganister as there was between the electrode and the original roof hole.

G illustrates the earliest attempt the author made to remove the sealing of the electrode away from the roof. This was not successful because of the still red hot electrode above the roof burning away in the air.

H illustrates the result of the above short economiser. From this drawing will be appreciated the very small advance that this or any other short seal constitutes over the early methods of sealing.

J (Fig. 8) and Fig. 9 show the present-day economiser which forms the subject of letters patent. It is only by removing the electrode seal to a position well above the roof where the electrode is always below combustion tmperature that the effectiveness of the present scheme is obtained.

K and L show the same principle of economiser in telescopic form suitable for furnaces having only a short electrode travel. The conditions that exist in an electric steel furnace are even more onerous than an inspection of these drawings would lead one to assume. The reason for this is that electrodes are not raised only when a fresh charge is put into the furnace, but they are being raised or lowered constantly for the ordinary regulation of the current on the furnace. The effect of this necessary regulation is that the electrodes are moved an average of once each 5 to 10 seconds during the first third of the process, an average of every half minute during the second third, and an average of every minute during the last portion of the process.

This most important advance in electric furnaces gives results much beyond what might be expected from so simple a device, several of the improvements being as follows :—(1) No cold air is drawn into the furnace. (2) No flames or highly heated air burn away the electrodes above the roof. (3) A really reducing carbon-depositing (when desired) atmosphere is maintained within the melting chamber. (4) The oxygen-free atmosphere of the furnace prevents the burning of the electrodes inside the furnace except at the arcing ends, and, therefore, electrodes remain parallel instead of tapering. (5) The electrodes can be of smaller diameter for a given current supply. This, in addition to cutting down electrode costs, permits a reduction in the size of the electrode holes in the roof, thereby adding great strength to the roof (6) The life of the roof is considerably increased because the thick carbonaceous atmosphere inside the furnace acts as an opaque curtain through which the intense heat of the arcs cannot be radiated upwards to the roof. (7) The flames inside the furnace, not being able to pass out at the electrode holes, travel all over and among the charge and heat this up rapidly and very economically. (8) The electrode gear over the furnace does not become intensely hot as in older furnaces. Any adjustments required in the electrode gear over the roof can therefore be done in comfort by the furnace attendants while the furnace is at top heat. The coolness of the gear renders the frequency of such adjustments negligible. In the same way the absence of the great columns of flames, which continuously rise through the electrode holes of other furnaces and which radiate intense heat all around, renders the Stobie furnaces much cooler to work. (9) In consequence of the exclusion of free air from the furnace, and the absolute control which this permits over oxidation, scrap steels containing oxidisable elements such as chromium, tungsten, manganese, and even vanadium, can be easily melted without losing the special elements from the bath. In other furnaces the major portion of such elements is first oxidised out of the charge into the slag and has, then to be skilfully recovered, if possible, at great expense in time and current. When melting scrap which it is desired should not change at all in analysis, the carbon content does not vary by more than a point up or down. It is thus not necessary to analyse the molten bath in order to adjust the carbon and other elements when melting scrap giving the arithmetical proportions of the desired composition. (10) The absence of heat from the electrode gear enables the current terminals of the electrode to be made of light copper contacts built up of standard copper bars, instead of the usual intricate, heavy, water-cooled bronze castings necessary in other designs. (11) By preventing the heavy heat losses which formerly took place, the cost of manufacturing electric steel has been correspondingly reduced and the time required per heat diminished. (12) The sealing of the roof of furnaces by means of the economiser results in the furnace being much cooler for the furnace men to operate. This and the increased output from the plant very greatly reduce labour considerations for a given output of steel. This is of great moment nowadays in view of the high cost of labour.

Circulation of Bath.—Claims are made by some furnace manufacturers that, by reason of the electrical system or the position of the current circuits in their furnaces, an automatic stirring or circulation of the molten-metal bath takes place. It is also claimed that, in consequence of such circulation, no manual rabbling of the charge is necessary.

A careful research on the subject has been carried out at the Stobie Steelworks, and the results are of interest. Many years' observation of the working of electric steel furnaces had not revealed any movements of the steel bath except such as were due to well-known causes; therefore it was decided to devise means whereby closer observation of the effects of electric circuits through molten metal could be made than was possible in a steel furnace working at temperatures up to 1,800 deg. C. Mercury presented itself as a suitable substitute for a hot steel bath, as it resembled molten steel in being a liquid metal and magnetically inert. The resistivity of mercury at atmospheric temperature is approximately two-thirds that of molten steel. Its specific gravity is twice that of molten steel.

Separate experiments with single-, two-phase, and three-phase currents, and representing every known type of furnace with arcs playing on the bath, were made.

The size of the bath, the quantity of mercury, and the current flowing were proportioned to represent average practice, but on a reduced scale. Two voltages were separately used for each system of connections : one low enough to enable the full current to be passed through the bath without arcs, and a higher one to pass the current through arcs above the bath as in normal steel melting.

All the different furnace systems exhibited the same effects when current was switched on.

At low voltage, with the electrodes immersed in the metal, the observed motion of the bath consisted of a very faint pulsation coincident with the periodicity of the current. The amplitude of the pulsation was greatest near each electrode and diminished with distance according to the law of inverse squares. These vibrations which originated at each electrode were so small that they were detected at the surface only by the minutely throbbing reflection of incident rays. There was no trace of a circulating or swirling motion in any part of the molten bath.

As solid conductors heavily loaded with alternating current always vibrate, it was considered that the minute waves observed in the mercury bath might originate from the vibration of the electrodes immersed therein and not from the passage of the current through the liquid metal, in consequence of the much

greater area of the latter. Therefore the current was next made to flow round entirely-insulated copper circuits immersed in the bath. The same types and strength of electric current were employed as in the previous experiments. Exactly the same pulsations were noticed at the surface of the bath and a total absence of flowing motion.

The flowing movement of the slag under the arcs, visible in an electric steel furnace when the bath is covered with a fluid slag, has doubtless given rise to the common belief in a stirring of the metal bath by the current. The movement in the slag results, however, from the blowing action of the electric arcs, and it will stop immediately if the electrodes be lowered into the slag.

During the course of the above experiments it was noted that the greatest pulsating disturbance of the mercury was when the arcs played directly upon it. That disturbance was purely local and diminished considerably when a highly conducting fluid "slag" was placed on the metal. The violence of the blowing action of an alternating arc on liquid metal is observed in a commercial electric furnace if an arc is struck on to the bare steel after the removal of the slag. The steel will be blown away downwards from the electrode end and, on rebounding, will usually short-circuit the arc. The addition of a fluid slag will relieve the metal of the disturbance, as the slag will take up the flowing effort. The research conclusively proved that no circulatory or other stirring movement of the bath results from the electrode circuits in an electric arc furnace. The more or less complete diffusion of added elements which takes place in a bath of molten steel is a metallurgical phenomenon that occurs in all steel-melting furnaces, whether electric or other, and does not depend upon magnetic or convection currents. No special conditions exist in any electric arc furnace which will relieve the good steel melter from the necessity of properly rabbling his furnace bath.

Developments in Electric Iron and Steel Furnaces.

By J. Bibby.

The author proposes to confine his remarks in this Paper to some of the recent developments in the manufacture of iron and steel by means of electric furnaces, as he imagines this will be more acceptable than to treat the whole subject generally.

Let us first consider the application of electricity to the reduction of iron ores, namely, to the manufacture of pig-iron. Iron occurs in nature in the form of oxides, which can be reduced in contact with carbon at certain temperatures. In the electric furnace the function of electricity is to bring the ores and reducing agents to the temperature at which reduction takes place and then melt the resulting metal as well as the fluxes. Although there are technical advantages in electric heating over direct fuel-heating, the commercial success of the electrical reduction of iron ore depends on the price of electricity as compared with that of fuel. The profitable application of the electrical process is therefore limited to those districts where cheap electric power can be obtained.

The manufacture of pig-iron in a blast furnace requires, on an average, one ton of coke per ton of pig-iron produced. Given the same ore, an electric furnace would require 0.3 ton of coke per ton of pig-iron produced, thus effecting a saving of 0.7 ton of coke per ton of iron. Against this saving in coke must be set the consumption of electrical energy, which averages 0.3 h.p.-year per ton of iron. This means that, other conditions being equal, the costs of the two systems balance when 1 h.p.-year can be obtained for the price of 2.3 tons of coke.

Electric pig-iron contains less impurities than pig-iron from the blast furnace, owing chiefly to the smaller quantity of coke used and to the higher temperature obtainable. The higher temperature makes it possible to work with a more basic slag, which favours the elimination of sulphur. There are now over 20 electric furnaces working on the manufacture of pig-iron, and, at the moment, about 12 more are being installed, which is a good indication of the commercial hold the system is taking.

The general appearance of the electric reduction furnace follows that of the blast furnace fairly closely. The stock charging and hoisting gear are the same. The shaft is somewhat similar, except that it is only about 30 ft. high instead of 80 ft. At the point corresponding to the tuyere belt in the blast furnace the shaft proper of the electric furnace ends, and, in place of the narrow blast furnace hearth, there is provided in the electric furnace a wide shallow hearth or crucible, the shape of which is characteristic. This crucible forms the melting and refining chamber, and it is with the occurrences in this chamber that the electrical engineer is chiefly concerned.

In the blast furnace the necesary heat is generated in the tuyere zone by the combustion of the coke indirectly to CO. The hot combustion products ascend the shaft and reduce the ore in the zone in which a sufficiently high temperature obtains. The reduced iron, in the form of sponge, descends the shaft and is melted in the fusion zone round about the tuyeres, whence it trickles down to the hearth. In the electric furnace the necessary heat is generated by the resistance to the passage of current between the electrodes, which project through the roof of the crucible and are embedded in the charge.

At this stage we may consider the chemical action taking place in the electric furnace. The iron ore, coke, and flux are charged at the top of the furnace, and these, in descending, are heated by the ascending gases generated at the base of the shaft and top of the crucible by the final reduction which takes place in this region. When the temperature of the ore, Fe_3O_4, has reached about 250 deg. C., it is reduced to a lower oxide, FeO, by part of the ascending CO, forming CO_2. The full reduction process can be set out as in the equations (1) and (2) in Fig. 1.

$$Fe_3O_4 + 3C + 3CO \rightarrow 3FeO + 3C + CO_2 + 2CO \quad . \; . \; . \quad (1)$$

$$3Fe + 3CO \leftarrow 3FeO + 3C \; . \; . \; . \; . \; . \; . \quad (2)$$

Fig. 1.

of carbon charged to 56 of iron produced, that is 22 per cent., and it is satisfactory to find that, in the furnaces built recently, no more than this quantity of carbon is consumed per unit of iron produced. The first reduction to ferrous oxide by CO is at the temperature of 250 deg. C. mentioned above, but the reduction of the ferrous oxide by solid carbon does not commence until a temperature above 800 deg. C. is reached, so that reduction is not completed until part of the oxide is in the crucible.

It will be noticed from the equations that in the electric process the whole of the gas is produced from the oxygen in the ores and the carbon in the fuel, neglecting flux action, whereas in the blast furnace a large quantity of external air must be introduced to provide the balance of oxygen necessary for the combustion of the fuel for heating. In the electric furnace the gas generated is only one-eighth of that

It will be seen that with every molecule of magnetite ore there should be three molecules of carbon, and this carbon descends, without change, till the temperature is sufficient for the reaction, equation (2), which shows that the final yield is three molecules of iron which descend, two of CO and one of CO_2 which ascend; so, theoretically, there are 12 parts by weight generated in a blast furnace for the same duty, but its calorific value is nearly three times as high, because it contains no nitrogen.

Besides the melting and final reduction operations in the crucible, we have to melt the flux so as to form a slag with the gangue of the ore and the ash of the coke, and at the same time eliminate as much as possible the sulphur introduced by the ore and the coke. The sulphur is eliminated through the agency of the lime, forming calcium sulphide, which is retained

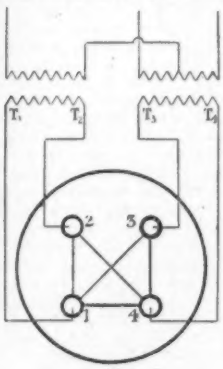


FIG. 2.

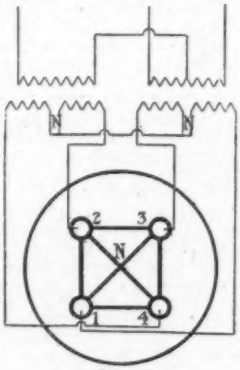


FIG. 3.

in the slag. The slag should be highly basic in order that it may absorb the sulphur, which would otherwise remain in the iron as sulphide of iron. This necessitates a high temperature, owing to the high melting point of lime; but it would be futile to have a high temperature at one part of the metal-slag contact area and a low temperature at another, as in that case the sulphur would pass back from the slag into the metal at the cold places, and neutralise the good work at the hot places. The heating system must therefore be arranged so as to develop a uniformly high temperature throughout the central and lower portions of the crucible. We can now consider the means which are taken to accomplish this thermal state.

As before mentioned, the heat is developed by the resistance of the loose charge to the passage of current between embedded electrodes. It is difficult to ascertain the voltage gradient throughout the charge, in the varying form in which it appears in the crucible, where it consists of ferrous oxide, melting iron, gangue, fluxes, and small portions of coke. It appears, so far, impossible to obtain as high a voltage drop across the crucible as we should like; and the drop does not increase quite in proportion to the distance, indicating, as would be expected, that there is a considerable drop between the electrodes and the material, which drop is constant for any given electrode and current. The effect is to have a higher rate of heat generation around the electrodes than in the intermediate spaces. However, it does not materially affect matters if we consider that the resistance between the electrodes is uniform throughout the space between them, *i.e.*, that it is proportional to the distance.

It will be obvious that the larger the furnace the greater will be the number of electrodes required to distribute the heat sufficiently; and further, since up to the present no electrodes have been made having a greater capacity than 20,000 amperes, a number of electrodes are required to get the desired quantity of energy into the furnace. The main factor, however, is distribution. The following table gives the number of electrodes used on various sizes of furnaces and the outputs :—

Horse-power.	Number of electrodes.	Yearly output.
2,500	4	7,000 tons
4,000	6	11,500 ,,
6,000	8	18,000 ,,
10,000	12	31,000 ,,

Commercially the smallest furnace is the 2,500 h.p., with an output of 7,000 tons of pig per year. In this furnace we have four electrodes coupled to the secondary terminals of a Scott group; and the first scheme was to connect them as shown in Fig. 2, where the lower part of the diagram represents a horizontal section through the crucible at the ends of

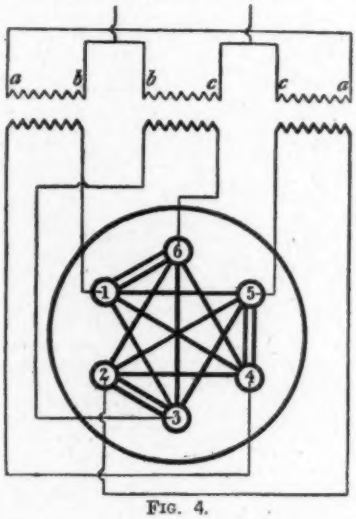


FIG. 4.

the electrodes Nos. 1, 2, 3 and 4. The voltages across the electrodes 1-2 and 3-4 will be equal, but the voltages between the other pairs of electrodes need not be the same; for instance, there is no need for any voltage drop between electrodes 2 and 3, in which case there would be no current passing between these electrodes and no heat generated in the space between

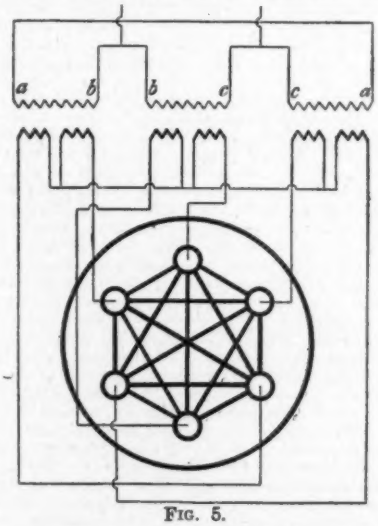


FIG. 5.

them. Similarly, the voltages between electrodes 1 and 4 may be 1.4 times the phase voltage, and in this case there would be an excess of current, and consequently excessive heating, between electrodes 1 and 4. The lines between the electrode circles represent roughly what may be considered to be the lines of

heat generation in the crucible. The effect was to produce excessive heating at certain places, for example, between 1 and 4 electrodes, and deficient heating at other places, say between electrodes 2 and 3, resulting in irregular working and, what was of serious importance, undue destruction of the lining, especially of the roof near the overheated portions. This difficulty was overcome in a very simple manner as shown in Fig. 3, where the neutrals on the secondary delta-connected on the primaries, and the terminals of the secondaries connected to diametrically opposite electrodes, as shown in Fig. 4. Although this arrangement secured equal voltages between diametrically opposite electrodes, it by no means ensured regularity of voltages between the other pairs of electrodes; for example, there was no cause for any voltage drop between electrodes 1 and 2, and it was possible to have as high a voltage between adjacent electrodes 1 and 6

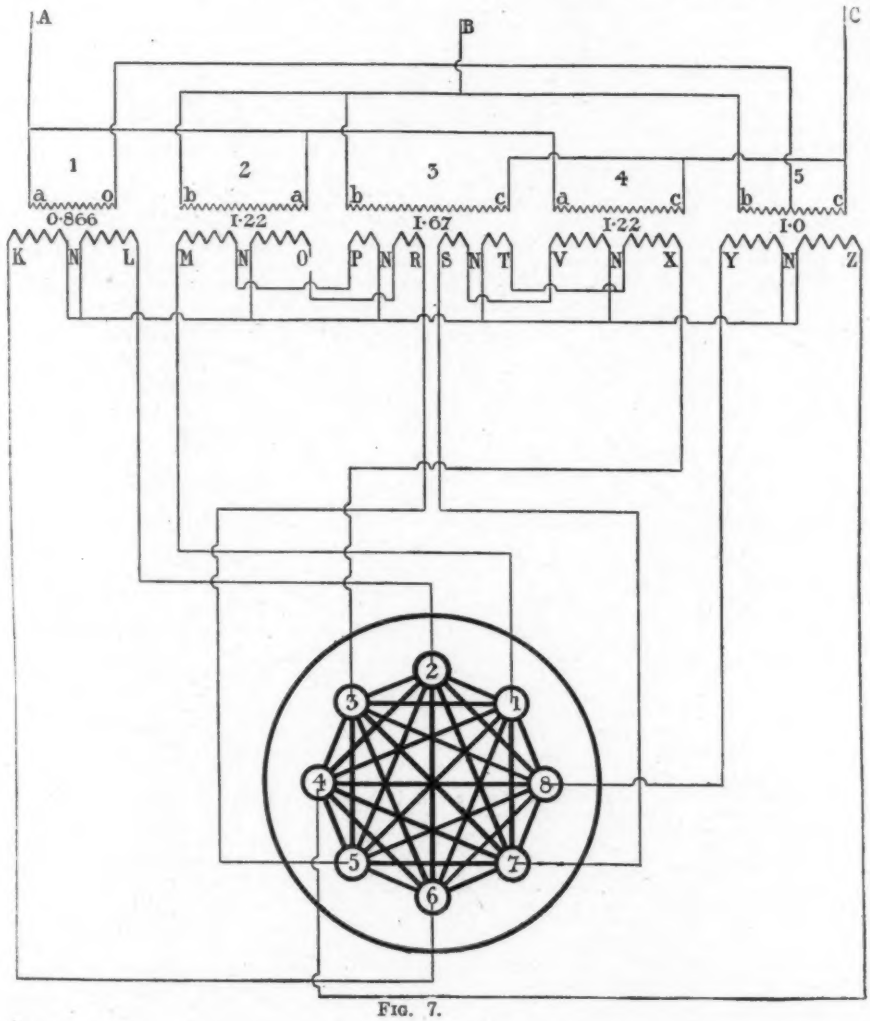


FIG. 7.

side of the Scott group were connected so as to obtain the effect of four equal independent phases between each electrode and an imaginary neutral point N. The potential between the electrodes and the neutral can be represented by the semi-diagonals, and that between the electrodes, externally, is 1.4 times the voltage to the neutral. These voltages are proportional to the respective distances, so that the rate of heat generation along all the lines connecting every pair of electrodes will tend to be uniform.

The next size of furnace, viz., the 4,000-h.p., requires six electrodes, and the idea on the early furnaces was to employ three single-phase transformers, as between diametrically opposite electrodes. The result was a very irregular distribution of heat. There were zones of intense heat and zones where the heating was insufficient and, as a consequence, deficient working and local destruction of linings. The trouble was remedied, as in the four-electrode system, simply by connecting the neutrals on the secondary side so as to secure the three phases being relatively fixed, and obtain the equivalent of six equal phases at 60 deg. The heating effect is approximately as shown by the lines in Fig. 5, and the improvement is obvious on comparing the two diagrams.

The next size of furnace, the 6,000-h.p., has eight

electrodes and, for many reasons, it appears that this is destined to be the most popular size. For this furnace we require to transform three-phase current into eight equal phases consecutively at 45 deg. There may be other ways of obtaining this transformation statically, but the plan which has been adopted is that which will now be explained. Five transformers, with relative ratios as marked, are connected on the primary side as indicated in Fig. 7, and the secondary terminals are connected to the electrodes in the order shown. The neutrals are connected for the same reason as on the smaller furnaces. When correctly proportioned, we obtain eight equal voltages induced between every electrode and the neutral. From the voltage vector diagram (Fig. 8) it will be seen that the voltage between No. 1 electrode and the neutral is equal to the vector sum of the voltages induced in NP and NM and represented in the diagram by OP and OM, giving the resultant E_1. Similarly, the voltages between the other electrodes and the neutrals are represented respectively by the equal vectors E_2, E_3, E_4, E_5, E_6, E_7, and E_8, at 45 deg. progressively, which satisfies one condition of the system.

From the electric supply standpoint it is important that when equal currents are taken through all the electrodes, three equal currents should be taken from

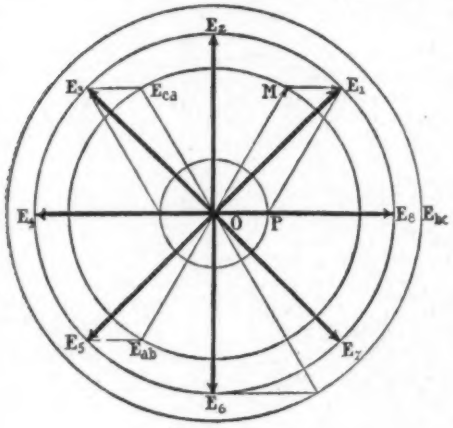


FIG. 8.

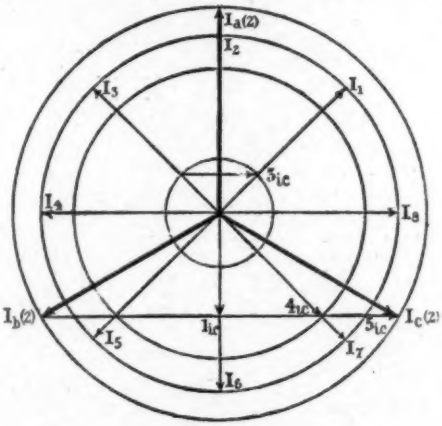


FIG. 9.

the primary mains. Fig. 9 is the current vector diagram, from which the current relationships can be followed, assuming that equal currents are taken through each electrode. The lines 1*ic*, 5*ic*, 3*ic*, and 4*ic* represent the currents induced in the primary C by the respective transformers. The vector sum of these currents is twice 1 Similarly, the currents in the other primaries are represented by twice 1_a and 1_b. This system satisfies the electrical condition for balance between the primary and secondary sides, and at the same time secures an exceptionally good heating distribution.

It will be observed that, if the electrodes are set out as shown in the diagram, the effective voltage between any pair of electrodes is proportional to the distance between their centres, and, consequently, if the resistance were constant, the amount of heat development could be represented by the lines drawn between the pairs of electrodes. As previously explained, this is not precisely what happens, since there is a constant voltage drop between the surface of the electrodes and the adjacent material.

The securing of a uniformly distributed high temperature gives the electric furnace an advantage over the blast furnace in this respect. In the blast furnace the temperature of the hearth is fixed by the possible temperature of the combustion at the tuyere zone, say 1,800 deg. C., and this determines the melting point of the flux, that is, the possible proportion of lime. Now, in the electric furnaces we have no such limiting temperature, and it is possible to have a flux with a melting point of 2,000 deg. C., which permits of its being more highly basic and therefore more effective as a refining agent.

It might appear that the current passes horizontally between the electrodes, but this is not exactly what takes place in the crucible, as a portion of current is deflected through the molten metal on the hearth. Consequently, as the bath of metal rises, the resistance decreases, until a point is reached when it is impossible to get sufficient energy into the furnace, and the bath must then be tapped. This limit corresponds to that set by the height of the tuyeres in a blast furnace; but the growth of the bath is much slower, owing to its greatly superior width. An electric furnace is tapped every 4 or 5 hours to suit the shifts.

The high temperature in the crucible would be destructive to the roof, even with regular heating, and to avoid this a portion of the outgoing gases is extracted from the main, taken through coolers and dust extractors, and blown against the roof through the free space between the charge and the roof. The gases are cooled to a temperature of about 70 deg. C., and it is found that if about two-thirds of the gases are circulated the roof is effectively preserved. At the same time, this circulation assists in carrying the heat from the crucible into the shaft so as to effect the first reduction of the ore at a higher level. It will be observed that under this arrangement all the gas generated passes, on the average, three times through the shaft; but there is a distinct thermal loss by the amount of cooling necessary.

To ensure the proper working of the furnace under the inevitably varying conditions of the charge, it is necessary to have full control of the circulation gases and the electric energy delivered to the crucible. Regarding the energy supplied, it is not possible to have regulation of current, but the transformers are arranged with tappings on the pimary side so as to give about eight steps of voltage on the secondary, varying from 25 to 50 between the electrodes and the neutral. The circulating gases are regulated by a direct-current motor-driven fan with wide speed regulation.

The general electrical scheme of a 4,000-h.p. six-electrode furnace is shown in Fig. 6, which is fairly self-explanatory. It will be observed that a motor-generator set is fitted for operating the fans. The single-phase transformers are of 1,200 k.v.a. each, shell type, water-cooled, with connected neutrals.

One of the most important points for consideration

on the electrical side is the arrangement of the low-tension leads; each lead has to take a current of the order of 20,000 amperes, and therefore the greatest care must be taken to avoid induction. As an example of the losses which may occur in the low-tension leads, it was found, in a test on an early furnace, that the output from the transformer was about 4,000 kw., but the input to the electrodes was 3,400 kw., showing a loss of 600 kw. The losses were distributed as follows :—

In the contact clamps at the electrodes...	120 kw.
In the resistance of the leads	165 ,,
By induction	315 ,,
Total losses.....	600 kw.

The heavy induction losses were chiefly caused through the leads having to pass near the structural ironwork of the furnace. By re-arranging the leads and interleaving the bars the induction losses can be brought down to about 50 kw. On well-designed plants a power factor of 90 per cent. is obtained, and a load factor of 80 per cent.

The power consumption per ton of pig-iron produced depends chiefly on the percentage of iron in the ore, on the percentage of CO_2 in the waste gas, and on its temperature. The ideal process would be to burn the whole of the carbon to CO_2, but the reducing value of the gas rapidly decreases as the percentage of CO_2 increases, until a point is reached when reduction ceases. In the electric furnace it has been found possible, under the best conditions, to approximate to the equation previously given where the final gas consists of $2CO+CO_2$, which gives 56 of CO to 44 of CO_2 by weight, that is, 44 per cent. of CO_2, which is equal to about 33 per cent. of CO_2 by volume. Fig. 10 shows the consumption of energy for various percentages of iron in the ore, and various percentages of CO_2, by volume, in the waste gases. In a good case of 33 per cent. CO_2 and 70 per cent. iron content, the consumption was only 1,320 kilowatt-hours per ton.

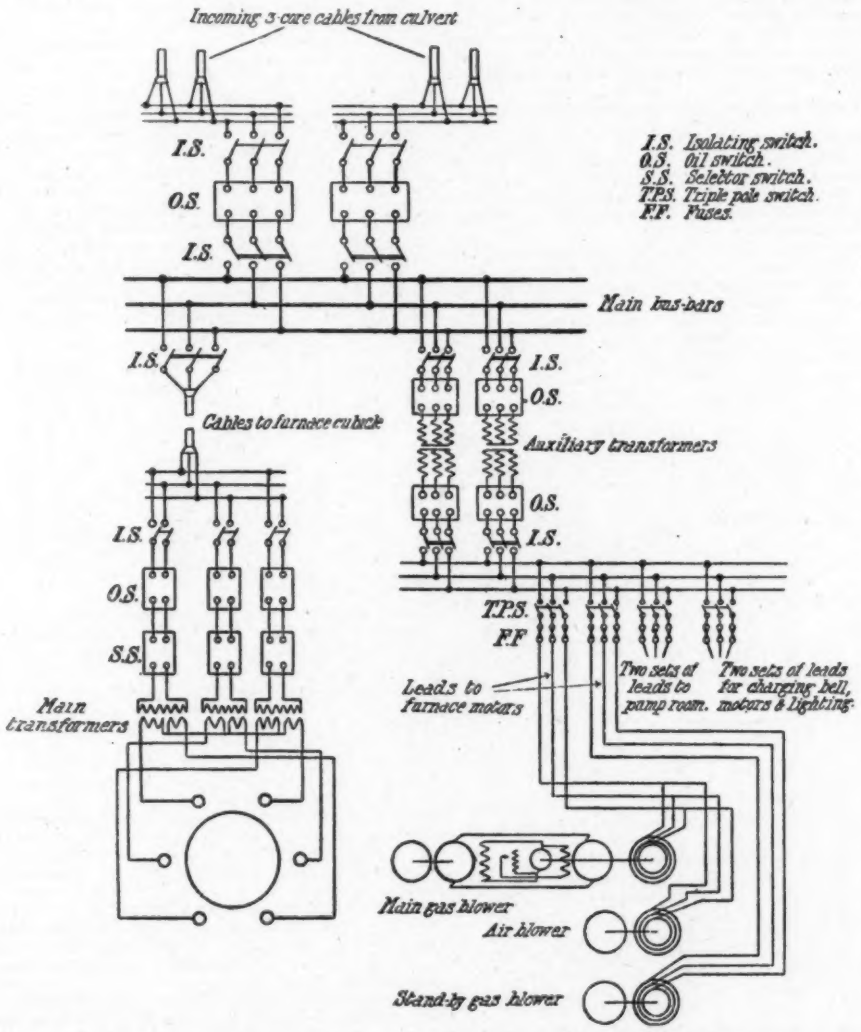


FIG. 6.—DIAGRAM OF CONNECTIONS FOR SIX 4,000-H.P. ELECTRIC REDUCTION FURNACES.

The average obtainable, however, is 22 per cent. of CO_2, and with, say, 60 per cent. iron content the consumption is about 1,500 kilowatt-hours per ton. The consumption of fuel is given in the lower diagram, where the bottom line indicates the consumption of pure carbon, and the top line that of coke per ton of pig. It will be seen that for 22 per cent. CO_2 the consumption of coke is only about 6 cwt. per ton of pig, excluding that required for carbonising the iron, and this is a common figure in practice.

The working of the electric reduction furnace requires quite as much skill as the working of the blast furnace, but it is under better control and has greater possibilities for the production of various grades of iron.

Electric Steel Refining Furnaces.

The application of electricity to steel-refining has become much more general than to the manufacture of pig-iron, inasmuch as in the former the price of electrical energy, although an important factor, is not the predominating one in determining the commercial value of a proposition.

In steel-making, electricity has advantages which place it well ahead of other heating systems. The chief of these advantages is that the heat can be supplied in easily adjustable quantities and intensities, free from contaminating gases. Moreover, the process can be carried on in a reducing atmosphere, which is of capital importance. Of the many methods of applying electricity that have been tried, the only one which

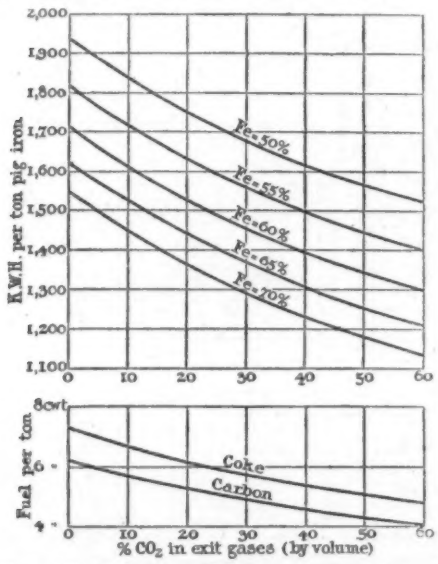


FIG. 10.—FUEL AND ENERGY CONSUMPTION FOR ELECTRICAL REDUCTION OF MAGNETITE (Fe_3O_4).

has survived is the direct-arc type, in which the metal is heated by arcs struck between electrodes and the bath of metal itself. An incidental advantage of this system is that the slag is brought to a higher temperature than the metal, which is very desirable on account of its higher melting point, and, further, it is the most direct method of getting the heat into the metal.

In this part of the Paper the author will deal with only some of the features connected with this particular system. Two types of furnaces have been developed on these lines, one in which all the electrodes are above the bath, and the other in which the electrodes are both above and below the metal. The first point to observe is that the resistance between any two upper electrodes is equal to the resistance of two arcs (the resistance of the metal being negligible), whereas the resistance between an upper electrode and a lower electrode is equal to one arc plus the resistance of the hearth. Now, in order that a number of phases may be in balance, it is necessary that the resistances in the phases be equal; e.g., if we have a three-phase furnace system we must have three equal resistances. In the Héroult three-phase system there are three upper electrodes connected to the outside terminals of three single-phase transformers. In this system the resistance between each pair of phases is equal to that of two arcs, so that the arrangement gives a balanced system when correctly regulated.

If we have a three-phase system with two upper electrodes and one lower electrode, the resistance between the two upper electrodes will be equal to that of two arcs, and the resistance between either upper electrode and the lower electrode will be equal to that of one arc, plus the resistance of the hearth; so that, in order that the system may be balanced, the resistance of the hearth must be equal to that of one arc to bring the total resistance to two arcs, and this results in one-third of the energy being dissipated in the hearth. Now a basic hearth is a conductor of the second class, and the resistance decreases as a function of the rise in temperature. The resistance on the

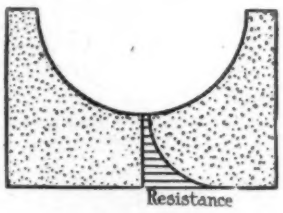


FIG. 11.

hearth surface in contact with the metal, where the temperature is about 1,800 deg. C., is very small, but increases comparatively rapidly towards the bottom of the lining; so that the heat generated in the hearth, through its resistance, is principally towards the outside, away from the metal. The horizontal lines in Fig. 11 show the rate of heat generation throughout the depth of the lining. From this it will be seen that there can be no benefit to the metal through the generation of heat in the lining, but, on the contrary, it can be assumed that practically the whole of the heat thus generated is dissipated by radiation outside the furnace, rather than that any is absorbed by the metal. A three-phase furnace, or a furnace having any other number of phases, so connected, and depending on hearth resistance for balance, although it might seem the simplest plan to adopt, is bound to be wasteful in current consumption. For any system to be balanced, without the introduction of resistances other than the arcs, the number of arcs must be a multiple of the number of phases.

This brings us to the determination of the number of arcs which should be used in an electric furnace. From a mechanical point of view the fewer the arcs the simpler the system; but the minimum number is determined by metallurgical considerations. There must be sufficient heating zones to melt the raw material rapidly, without necessitating undue exertion in pushing the unmelted metal towards the melting zones, and, in refining, it is imperative that the metal and slag should be brought to a high and uniform temperature. The reason for this uniformly high temperature is that the basicity of the slag depends on its lime content, which fixes its melting point. The higher so that the higher the temperature the more possible it is to have a fluid, high basic slag. The extent of the chemical action is indirectly limited by the minimum temperature of the slag, so that in order to get

a uniformly high temperature, we must have no place in the furnace too far away from an arc, thus necessitating an adequate number of arcs to secure this condition.

Small furnaces have been made having a single arc, but it does not appear that any of these furnaces are in use for refining operations; they are simply employed for melting. There is the further difficulty of obtaining single-phase current from the usual three-phase supply without employing rotary transformers. It is found that two arcs sufficiently cover a bath up to about 6 tons capacity, and there is no necessity to employ more than two upper electrodes for furnaces up to this size. In order to satisfy the conditions for balance, without the serious hearth resistance loss before mentioned, the two-arc system employed must only have two phases with a common neutral and as little hearth resistance as possible. Fortunately, a dolomite hearth is a fairly good conductor at the working temperature, and the loss through a depth of 12 inches, which is an ample thickness for a furnace hearth, involves a drop of only two or three volts at a current density of 3 amperes per square inch. The two-phase current is readily obtained from a three-phase supply by the usual plan of Scott-connecting two transformers, or by employing two phases of the four-phase system (to be described later) with two phases cut out and the transformer ratios modified to give two quadrature currents.

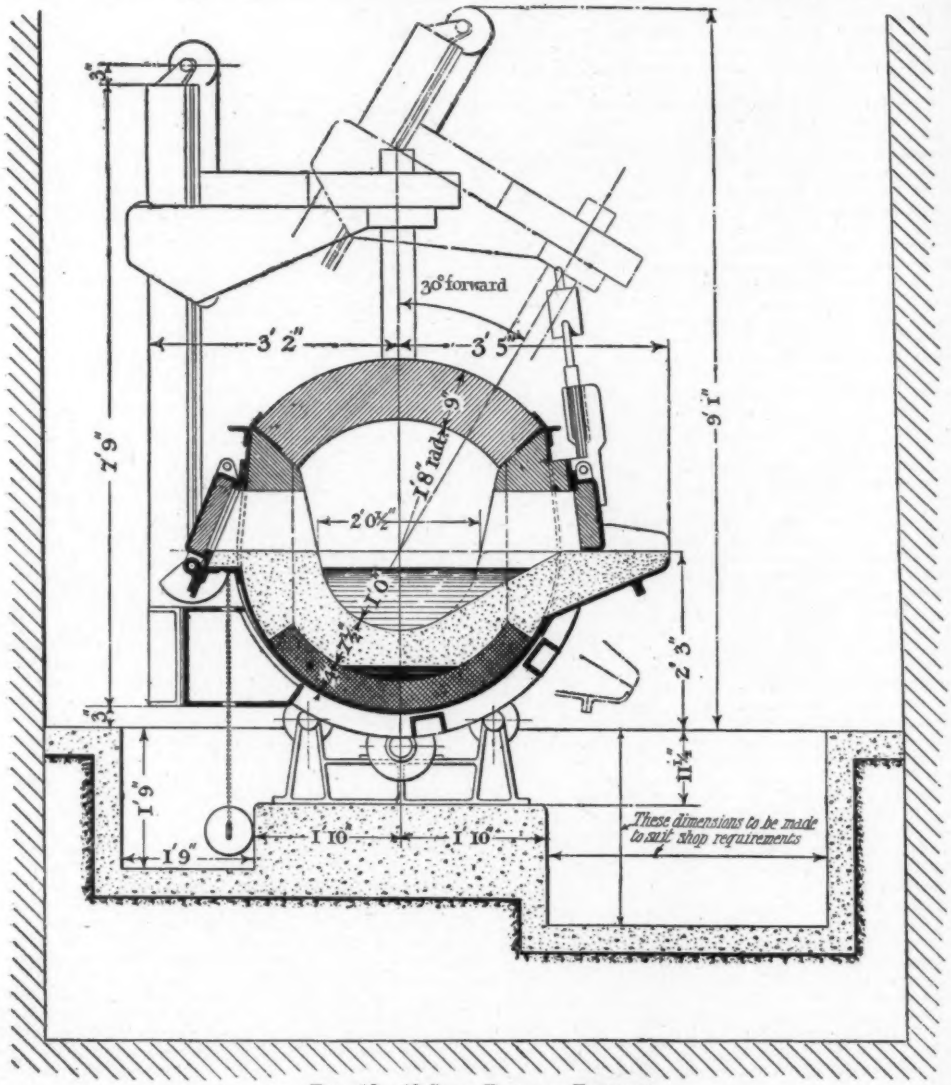


FIG. 12.—10-CWT. ELECTRIC FURNACE.

The main field for these small two-arc electric furnaces is in small foundries manufacturing better-quality castings, such as motor-car parts, etc. The castings made from the electric furnace are superior to those made from small converters, since the metal is thoroughly deoxidised and the sulphur content is reduced to a minimum. The predominating cause of

defects in steel castings, apart from moulding errors, is the presence of oxides, and the freedom from oxides in electric furnace metal is a positive step forward; also, owing to the reduction in sulphur, the metal is much more ductile and uniform in composition, so that electric steel castings are freer from contraction tears and are much more easily machined. Waster castings, which figure so largely in ordinary steel foundry work, are reduced to an almost negligible quantity. These small electric furnaces are also rapidly displacing the ordinary crucible furnaces for the manufacture of higher quality steels such as ordinary tool, spring, tungsten, nickel-chrome steels, etc. The electric furnace is able to manufacture accurately to specification all kinds of steel from the cheapest raw material, since the reducing atmosphere permits of the alloy additions being made practically without loss.

There is an important use for the small furnace of about half-ton capacity, and that is the melting of ferro-manganese for use in conjunction with open-hearth furnaces. When solid ferro-manganese is added to molten steel in the ladle, it is only reluctantly absorbed, and at least 30 per cent. of the manganese content is lost by oxidation. Portions of the manganese are liable to remain unabsorbed by the steel, and these form manganese ghost lines in working, and hard places which appear in machining. Ferro-manganese can be melted in the small furnace (Fig. 12) which has been specially designed for this purpose, and in which the manganese loss is not more than 5 per cent. There is therefore a great saving in manganese, which is an expensive metal; in fact, the saving soon pays for the cost of the furnace, and the steel product is of higher value. These small furnaces have a capacity of 10 cwt. and will deliver molten ferro-manganese at the rate of 400 lbs. per hour. The current consumption is 1,000 kilowatt-hours per ton of ferro-manganese delivered.

Although there are profitable fields for small furnaces, the prinicpal technical developments will take place in larger furnaces. These furnaces may be used either for the complete process of melting, refining and alloying, or may be run in conjunction with Bessemer or open-hearth furnaces, being used to refine the cruder metal from those furnaces. In this case, advantage is simply taken of a feature of the electric furnace, viz., that which permits of working under a non-oxidising atmosphere at any desired temperature.

As previously mentioned, it is important that the heat supplied should be well distributed over the slag-metal contact area in order to ensure that the chemical reactions take place regularly as required. These larger furnaces, consequently, require a greater number of heating zones, that is, a greater number of arcs. The furnace which will now be described has four upper electrodes, which are sufficient for furnaces up to 30 tons capacity, and two of this size are about to be started up on the Continent. This furnace is shown in elevation and plan in Figs. 13 and 14. The furnace is circular in plan, and the masts which support the electrode carriers are distributed round the furnace as shown. In the scheme of an electric furnace it is important to have as few openings as possible, and, at the same time, to have these so placed that every portion of the hearth can be surveyed and be accessible for any necessary lining repairs between the heats. Three doors are sufficient, one for teeming and two for charging, but this number is only sufficient if the doors are correctly placed and provided there are no obstructions to the men working at the doors. It will be seen that the disposition of the masts is such that all the mechanism is well clear of the doorways. The motors, which are the mechanisms nearest to the doors, are below the working platform. The doors must be designed to be always free to move and to form a good seal when closed.

The electric system on the large furnace requires, for the reasons given, four equal phases, preferably with only one variable resistance in each phase to facilitate definite regulation. We therefore require four phases with a common return through the hearth, so that the resistance in each phase is equal to the varying resistance of one arc plus the constant resistance of the hearth. The arrangement, as used for a three-phase supply, will now be described. The four-phase five-wire system must be so arranged that the current through the hearth will be a minimum, and this can be taken as the current in one phase, so that when starting the furnace one full arc can be struck independently of the other three upper electrodes.

The system consists of three single-phase transformers, arranged as in Fig. 15, with the primaries delta-connected, and the secondaries in such a manner that, from the terminals of two transformers, Y, W, S, and R, connections are made to the upper electrodes 1, 2, 3, and 4 respectively; and from the centre M of the third, or teaser secondary to the neutral electrode, N, beneath the hearth. From the terminals V and T of the teaser, connections are made to intermediate points X and Z respectively on the other two or main transformers. When arcs are struck beneath the electrodes we have four practically independent circuits. The development of the system is shown clearly in the vector diagram. In Fig. 16 the three circles have radii corresponding to the transformation ratios of the sections of the secondaries to the corresponding primaries. If we consider the three primary windings to be equal, then the radius of the inner circle can represent the number of turns in the sections XW and ZS, the intermediate circle the turns in MV and MT, and the outer circle the turns in XY and ZR. The vectors E_{ab}, E and E_{ca} represent the directions of the voltages across the respective primary windings. The voltage induced between No. 1 electrode and the neutral is equal to the vector sum of the voltages induced in MV and XY; so that if we mark off along the directions E_{bc} and E_{ab}, distances E_{MV} and E_{XV} corresponding to the turns in MV and XY, the resultant E_1 will represent the voltage in the No. 1 electrode phase. Similarly, the voltages in the other phases are represented by the vectors E_2, E_3, and E_4. It is a simple matter to proportion the windings so that these voltages are all equal, but it is necessary when equal currents are taken through each of the electrodes, as is the case in normal working, that three equal currents be taken from the primary mains. That this is so will be seen from the current diagram (Fig. 17).

Neglecting induction, the currents in the electrodes can be assumed to be in the direction of the respective voltages, so that we redraw the voltage vectors obtained in the previous diagram and assume equal currents in the electrodes. The winding WY is under the influence of the currents in Nos. 1 and 2 electrodes. No. 1 electrode influences XY turns, and No. 2 electrode influences XW turns, so that if we mark off, along their respective directions, distances corresponding to the turns, for example, I_{XY} and I_{XW}, and the take the vector difference. I_{ab}, this will represent the ampere-turns in WY, and therefore in the primary *ab*. Similarly, the ampere-turns in *ca* are represented by the line I_{ac}. Concerning the winding TV, the current in MV is equal to the vector sum of the currents in electrodes Nos. 1 and 2, and the current in MT is equal to the sum of the currents in Nos. 3 and 4, so that if we mark off along E_1 and E_2 the intermediate circle distance, that is the turns in MV, and then take the resultant I_{MV}, this will represent the ampere-turns in MV. Similarly, I_{MT} represents the ampere-turns in MT, and the vector difference I_{bc} is the ampere-turns across TV, and therefore in the primary *bc*. As we assumed the primary turns to be equal, the lines I_{ab}, I_{bc}, and I will represent the currents in the primary windings, and the sides of the equilateral triangle constructed thereon, I_1, I_2 and I_3, are the currents in the primary wires. The system is therefore balanced for current and pressure under normal conditions of correct regulation.

An electric furnace is, however, inevitably and frequently subjected to abnormal conditions, and it is of

importance to know what is happening to the current in the mains when the furnace is working under the worst conditions. As far as the electrodes are concerned, the worst condition is when one arc breaks, as is so often the case. We will therefore assume, for example, that No. 3 phase is broken as in Fig. 18.

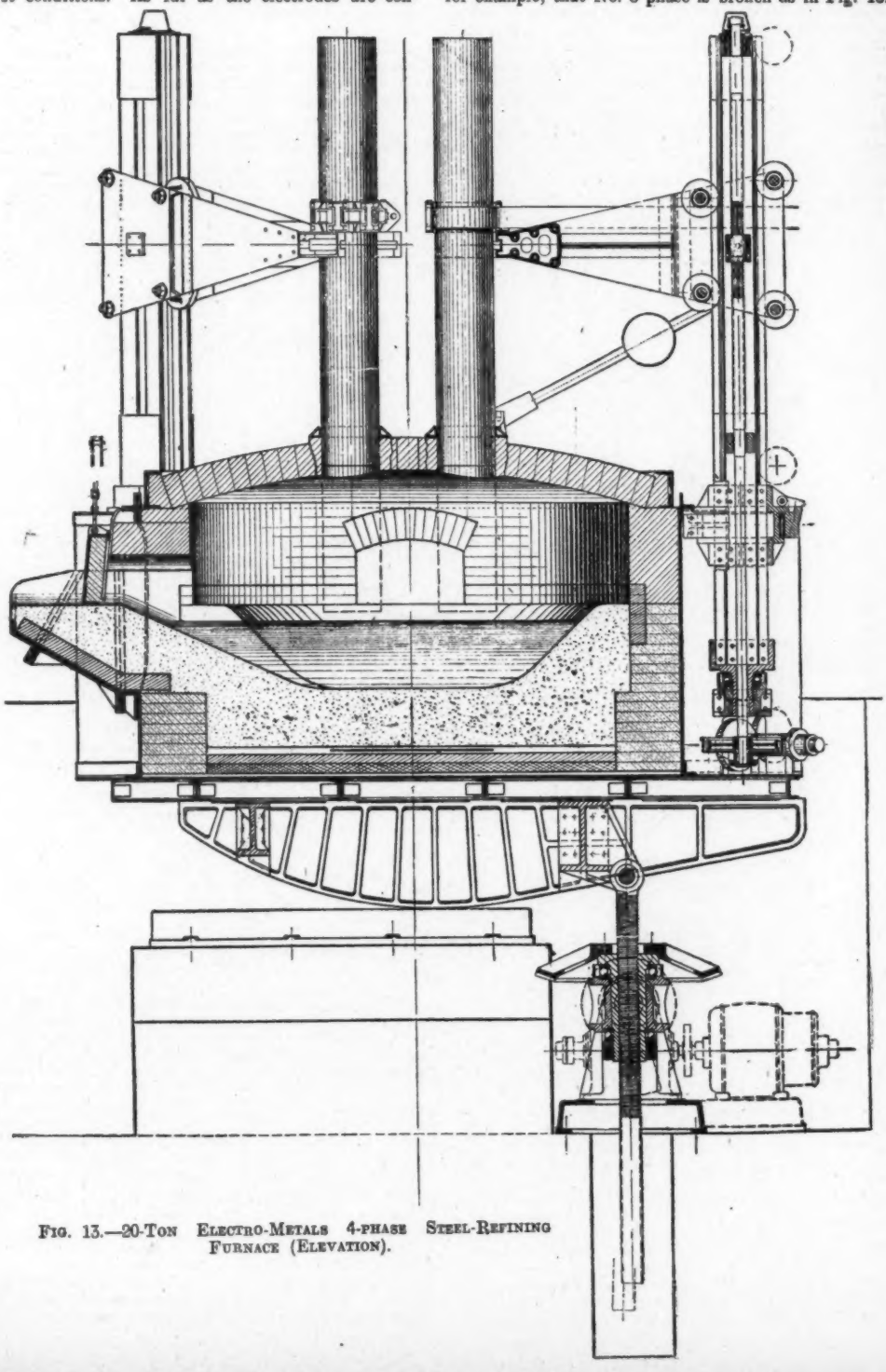


FIG. 13.—20-TON ELECTRO-METALS 4-PHASE STEEL-REFINING FURNACE (ELEVATION).

In the vector diagram, Fig. 19, we have the directions of the currents in the three remaining electrodes, as before, and we will assume that the three currents in these electrodes are equal. The winding WY is, as before, governed by the currents in Nos. 1 and 2 electrodes, and the ampere-turns across WY are represented by I_{ss}. The winding SR has only the current of No. 4 electrode and its ampere-turns are therefore represented by I_{ss}. For the teaser winding we have, as before, I_{MV} and I_{MT}; the difference I_{bc} will represent the ampere-turns in *bc*, so that we have the currents in the three primary lines represented by the sides of the triangle I_1, I_2, and I_3. The primary system is not balanced under this condition, but it is quite tolerable. Another extreme case is when one current through the hearth is, say, one-quarter the arithmetical sum of that in the whole of the electrodes. In the small two-arc furnace the current density is about 3 amperes per square inch: but on the four-phase furnace it is only 1 ampere per square inch, so that the drop in voltage is less than 1 volt, and the loss of energy in the hearth with this system does not exceed 0.3 per cent., and we have an arrangement which gives four independent phases, permitting of good electrode regulation. Careful tests have been made on a transformer group connected up on this system, as shown in Fig. 22. The electrodes were regulated so as to give as nearly as possible the same current, and then spot readings were taken on the ammeters on the primary side. The figures given in

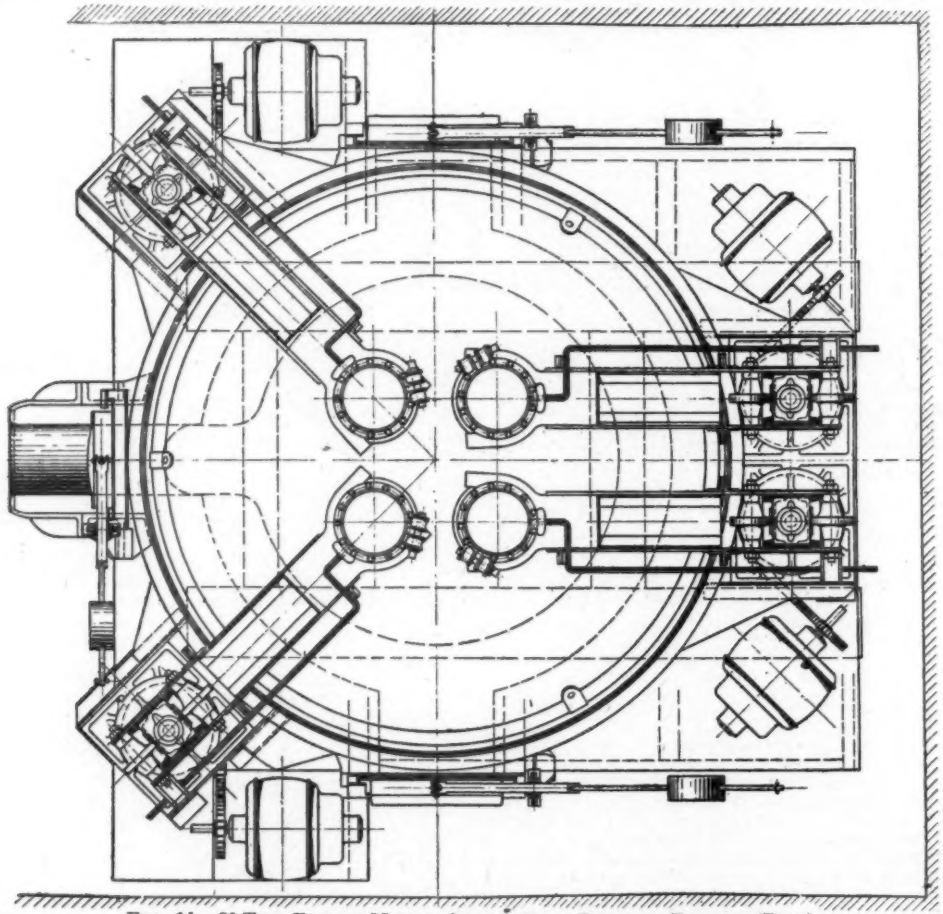


FIG. 14.—20-TON ELECTRO-METALS 4-PHASE STEEL-REFINING FURNACE (PLAN).

of the transformers has, for some reason, to be disconnected, as shown in Fig. 20. The currents in the primaries under this condition are represented by the three vectors I_1, I_2, and I_3 in Fig. 21, and it will be allowed that this is satisfactory.

It has been previously mentioned that practically all energy dissipated in the hearth is so much loss, and it is therefore important not only to reduce the voltage drop to a minimum, but also the neutral current. If we take this four-phase system, the current through the hearth is the vector sum of the currents in four electrodes, and this is approximately equal to that in one of them. This means that the volume of the diagram are percentages of the normal, and it will be noticed that the variations from the normal are less than 1 per cent., and the current in the neutral is 5 per cent. greater than that in the electrodes.

An interesting point in connection with arc furnaces is now the subject of an investigation, viz., the nature of an arc load. As is well known, the resistance of an arc decreases with an increase in current, so that with an alternating impressed voltage the specific resistance is at a minimum at the crest of the wave and at a maximum at the zero line. The resistance curve, therefore, has a full pulsation for each half wave of the fundamental current, and is at a maximum at 90

deg. from the maximum of the fundamental. This can be represented, as follows :—

If R is the resistance for the R.M.S. value of the current, and K the factor connecting the amplitudes of the two curves, then

$$r = R\left\{1+K\sin\left(90-2\omega t\right)^{2}\right\}$$
$$= R\left(1+K\cos 2\omega t\right)$$
$$i = \frac{e}{r} = \frac{E\sin\omega t}{R\left(1+K\cos 2\omega t\right)}$$
$$= \frac{E}{2R\left(1-K\right)}\left[\left(2-K\right)\sin\omega t - K\sin 3\omega t\right]$$

Both second and third harmonics occur, but if we develop the third, for example, in a Scott-connected group, we find that the harmonics are out of phase

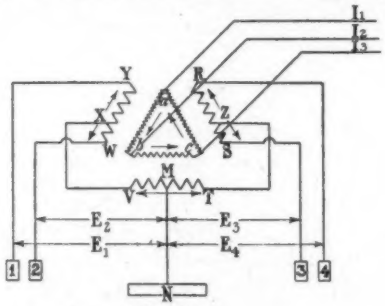


FIG. 15.

with two of the fundamentals, which is due to the fact that in such a group two of the third harmonics are the resultants of two third harmonics displaced by three right angles, which brings one resultant third harmonic 120 deg. out of phase with the fundamental. In the development of any transformer system for arc

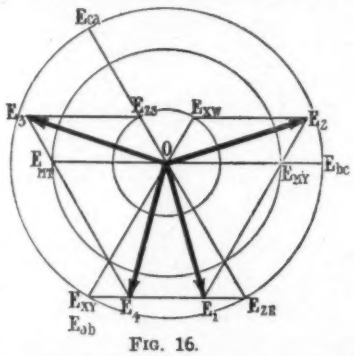


FIG. 16.

loads, the effect of the third harmonic must be taken into account, as it is necessary that the third harmonics in the primary should be as nearly as possible in phase with the fundamentals at the maximum, so that the curves will not be too unsymmetrical. In the four-phase system we have third harmonics in the four secondaries, and it is a simple matter to develop the harmonics back on to the primary lines and see that they are almost in phase with the primary fundamentals. The distortion of the primary voltage waves is negligible. Dr. Chapman has analysed one of these current waves on a Scott group (Fig. 23) and finds it can be represented by the following equation :—

$$i = 2{\cdot}34\sin\theta + 0{\cdot}202\sin 2\theta + 0{\cdot}168\sin 3\theta + 0{\cdot}566\cos\theta - 0{\cdot}43\cos 2\theta - 0{\cdot}17\cos 3\theta$$

This oscillogram shows the voltage-current relationship, and indicates a power factor of about 0.8. The small 27th harmonics on the voltage curve are from the transformer.

Among the first considerations in any proposal for installing electric furnaces are the available electric power and the price at which it can be obtained. Fig. 24 shows the capacities of transformers which must be supplied for given sizes of furnaces. It will be noticed that the capacity of the transformer required per ton decreases as the size of the furnace increases. This is because the radiation losses are proportionally greater in the smaller furnaces. Also, as is indicated on the same diagram, the consumption of current per ton decreases as the size of furnace increases. On a well-designed furnace the power factor is in the neighbourhood of 0.8, but it is necessary to have a large reactance, say 10 per cent. or 12 per cent., in the sys-

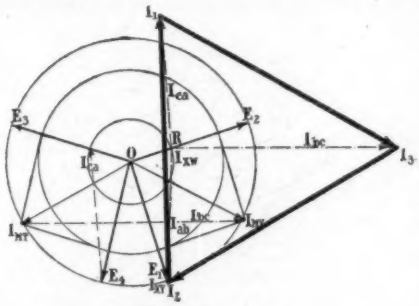


FIG. 17.

tem to choke the unavoidable fluctuations of current in the arc. From the electrical standpoint the most severe trial to which the plant can be put is when it is required to melt rough cold scrap, and when working on this duty momentary overloads of from 50 per cent. to 70 per cent. may occur, so that the trans-

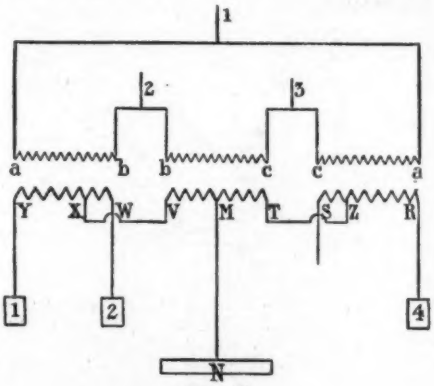


FIG. 18.

formers must be designed for such an emergency. The load factor on a single furnace working night and day is about 35 per cent., but when working two furnaces it is 50 per cent., which compares favourably with other loads on electric generating stations. It is unlikely that there will be much decrease in the consumption of current in the steel furnace of the future, since the thermal efficiency of a modern plant is about 65 per cent. Improvements will rather tend toward mechanical reliability and more durable refractories, especially for the roof. The metal will be melted in large plants by Bessemer or open-hearth processes and then charged into electric furnaces for refining and alloying. The electric furnace is not a cheap melter, its value being in its refining properties. When hot

crude metal is charged into the electric furnace the energy and time required for refining is about one-third of that required for melting and refining, so that a furnace charged with hot metal has three times the capacity of one charged with cold stock.

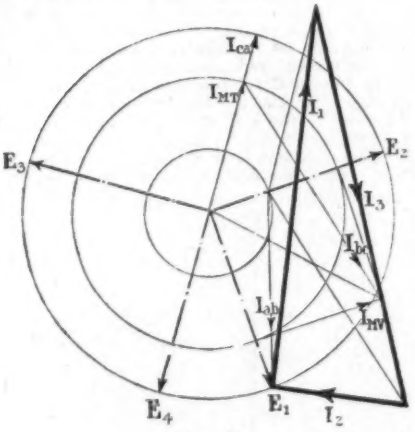


FIG. 19.

With respect to refractories, the electric furnace is practically always lined with a basic hearth, which shows it up to greater advantage in desulphurising. The hearth is built in exactly the same way as in an ordinary open-hearth furnace, so there is no need to

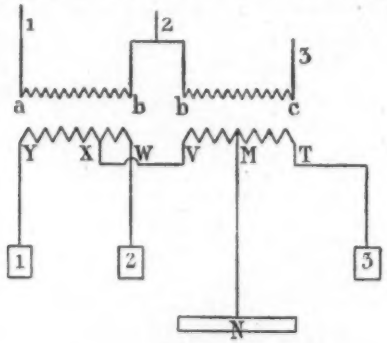


FIG. 20.

deal with it here. The average life of the roof is 100 heats, melting and refining, or about 400 working hours. During the war, when the cost of refractories was abnormally high, it was found that the average total refractories, including periodic relining, amounted to less than 8s. per ton of metal melted and refined.

only because of their initial cost, but also because of the time lost in renewing them. In the reduction furnace the electrodes are embedded in the loose material. They are not regulated as in the steel furnace, but are simply pushed down every two or three days as they burn away. Now on a 4,000-h.p. furnace with electrodes 28 in. in diameter embedded, say, 6 in. the area exposed to the material is about 1,000 sq. in. When passing 20,000 amperes the drop between an electrode and the material is about 20 volts, that is, the contact resistance is equal to 0.001 ohm. Since, in the

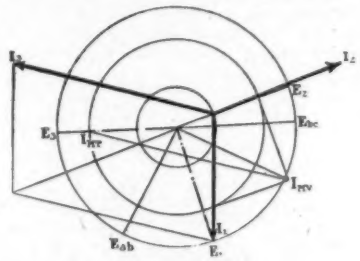


FIG. 21.

reduction furnace, it is desirable to have as great a voltage drop between the electrodes as possible, in order to get sufficient energy into the furnace, and as the distance between them cannot be increased conveniently, the only way to increase the voltage is to increase the drop between the electrode and the material; and to do this we must decrease the contact

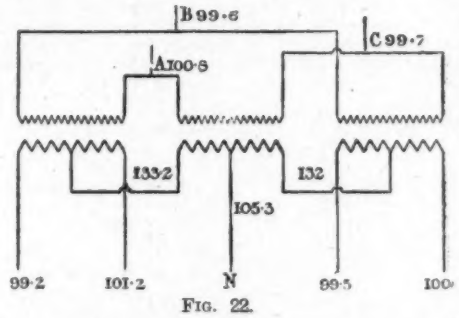


FIG. 22.

surface, that is, the size of the electrode. In the reduction furnace we are therefore confronted with the problem of requiring an electrode which has a greater conductivity than the carbon electrodes now being used, so as to reduce the contact surface. With carbon electrodes, when working at 40 amperes per square inch on the large 28-in. size, we have a voltage drop at each electrode of 20 volts, and about 40 volts in the resistance of the intermediate material, giving a total drop of 80 volts. If we had an electrode which

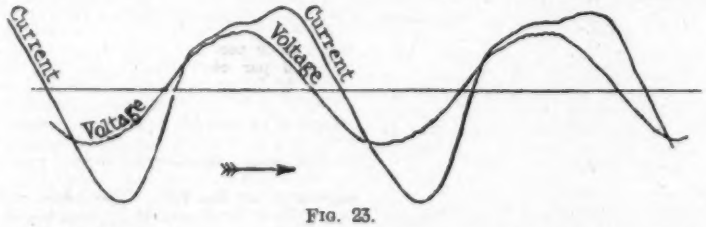


FIG. 23.

Electrodes.

One of the most important items in the cost of running an electric furnace is that of electrodes, not

would work at 120 amperes per sq. in., the diameters would only be about 16 inches, and the contact area about 500 sq. in., so that the electrode contact drop

would be 40 volts, giving a total drop between the electrodes of 120 volts. This would mean that, for the same size of electrodes and the same current, there would be 50 per cent. more energy delivered to the furnace. Graphite electrodes will work at a density of 120 amperes per square inch, but, unfortunately, they have not been made, up to the present, more than 12 in. in diameter. Electric reduction furnace builders are therefore waiting for the graphite electrode manufacturers to turn out much larger electrodes.

The skin effect on the large carbon electrodes is detrimental, and this would be reduced with the smaller graphites. Also, graphite electrodes will allow of smaller holes in the roof. On the other hand, it must be taken into account that the thermal conductivity of graphite is five or six times that of amorphous carbon, whereas it has only three times the electric conductivity, so that the drainage of heat from the furnace by graphite is twice that by carbon for the same

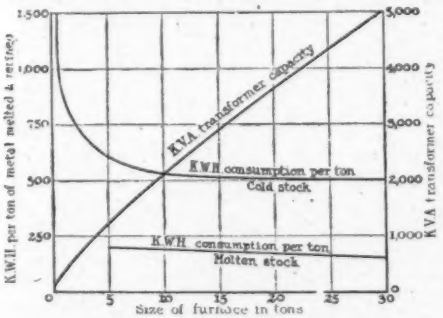


FIG. 24.

current-carrying capacity. In steel furnaces, where the resistance is simply the single arc, the surface is of no importance; the determining factor is the cost of electrodes per ton of steel.

Conclusion.

It will be seen that both the electric reduction furnace and the steel-refining furnace present interesting problems for electrical engineers, and that a fair amount of success has attended their efforts to solve these problems. Experience has shown how important it is that engineers should fully grasp the requirements of the metallurgists, and be fully acquainted with the working conditions of blast furnaces and of steel foundries.

Gas Standards.

In a letter dated June 26, 1917, the Fuel Research Board were asked by the Board of Trade and other departments concerned to advise as to :—" What is the most suitable composition and quality of gas and the minimum pressure at which it should be generally supplied, having regard to the desirability of economy in the use of coal, the adequate recovery of by-products, and the purposes for which gas is now used." The Board's conclusions are summarised as follows:—

(1) They do not consider that it would be to the ultimate advantage of any of the interests concerned that any one fixed standard of composition and calorific value should be prescribed. The arguments on this point are fully set out in the report.

(2) They propose that a new system of charging should be adopted instead of the present system. This may be summarised as follows :—(a) The consumer to be charged for the actual thermal units supplied to him in the gas which passes through his meter. (b) The thermal units chargeable to be calculated by multiplying the number of cubic feet registered on the meter by the calorific value per cub. ft. (c) This calorific value to be based on the usual test in the gas calorimeter, subject to any modification which may be accepted in the mutual interest of consumers and producers and sanctioned by the Board of Trade. (d) Subject to the acceptance by the gas undertaking of the stipulations laid down in these articles, the gas undertaking to be free to deliver to the consumer any mixture of the ordinary combustible gases free from sulphuretted hydrogen, and not containing more than 12 per cent. of inert constituents. (e) The gas undertaking to declare the calorific value of the gas it intends to deliver and to undertake to adjust the consumers' appliances for the ordinary purposes of domestic lighting, heating, and cooking, so that the gas delivered can be burned in these appliances with safety and efficiency. (f) Should the gas undertaking desire at any time to change the calorific value of the gas supply, due notice to be given to the consumers. (g) The gas undertaking to supply gas at such a pressure that, under normal conditions of supply and equipment, there shall be a pressure of not less than 2 in. of water on the gas at the exit of the consumers' meter.

(3) When more than one quality of gas is distributed to general consumers the foregoing stipulations should apply to all gas supplied.

(4) When gas for industrial use only is supplied in bulk, to be used exclusively in furnaces, muffles, steam boilers, water-heaters, gas engines, or in burners of any kind from which the products of combustion are efficiently removed by flues or exhaust fans and discharged into the open air at a height of at least 10 ft. above the level of the adjoining roofs, some relaxation in the foregoing stipulations may be permitted.

(5) With regard to sulphur purification, strong representations have been made to the Fuel Research Board on the desirability of the complete removal of sulphur compounds from gas.

(6) Though it is proposed that each gas undertaking shall be free to fix the calorific value which suits it best, the experience of the electrical industry in regard to lamps and voltages has shown that unlimited license in this respect has resulted in the needless multiplication of lamps and fittings for odd voltages which have to be made and stocked. It seems desirable, therefore, that before any legislation is undertaken the representatives of consumers, producers, and the makers of fittings and burners should jointly decide on the standardisation of burners in appliances for a limited number of calorific values. It is suggested that four standards may be sufficient: 400, 433, 466, and 500.

BRITISH SCIENTIFIC GLASSWARE.—According to Mr. F. W. Branson, numerous analyses and experimental meltings made with proportions of zinc oxide varying from 4 per cent. to 10 per cent. indicate that a percentage of alumina equal to about 6.5 per cent. of Al_2O_3, and a percentage of ZnO of 7.5 per cent. to 8.5 per cent. and of boric oxide (B_2O_3) about 7 per cent. will give a good glass if perfectly annealed, equal to all reasonable requirements for scientific work, provided the silica and alkali (or alkalis) are present in the best proportions. With regard to the presence of calcium oxide in glass similar to the above, it has been suggested that if zinc oxide is reduced in a formula for resistance glass, lime is the best substitute. The earliest satisfactory output on a manufacturing scale was obtained by the York Glass Company, who repeated Mr. Branson's laboratory experiments in their works, using cryolite as a part source of alumina. Analyses published in 1917 of all the British glasses then made show that all are better than any pre-war imported glassware, and that three of the series are superior to the other British glasses. A great aid to the industry would be the standardisation of hollow scientific glassware such as beakers and flasks as to shape, contents, weight, etc.

Correspondence.

Cast Iron and Official Specifications.

To the Editor of THE FOUNDRY TRADES JOURNAL.

SIR,—I read your comments on "Cast Iron and Official Specifications" in the April issue. It is highly gratifying to note that the British Foundrymen's Association is making a move in the direction of compiling suggested specfications. I entirely agree that this a move in the right direction, and I am sure that the official bodies concerned will welcome any assistance and suggestions put forward.

In reference to your remarks regarding the strong feeling of protest on the part of foundrymen against specifications including both physical and chemical properties, I am sure that this feeling is more apparent than real, and that any feeling of this nature will entirely disappear if more thoughtful consideration is given to the question.

In the first place I was entirely unaware of the fact that many founders have not been able to obtain the required physical properties when working to specified composition under the conditions of the specification. I do, however, admit the possibility of this state of affairs to a small extent, and on this account it seems to me to be all the more reason why both chemical analyses and physical properties should be linked together. The first object of any specification is to ensure uniformity of the particular product under consideration. This is necessary, because our knowledge of materials is very limited. Who is there who will state that we know all there is to be known regarding any metal and particularly cast iron? Owing to our lack of knowledge no specification can ensure complete uniformity, and we can only do everything possible in the present state of our knowledge with this end in view.

You dealt with the question of Air Board specification K6 for piston rings, and I was considerably surprised to find that "it was acknowledged that the chemical composition in this specification was not inserted to enable makers to get the best results." This statement is most emphatically wrong and is certainly misleading. In this specification is was found necessary, in order to meet other conditions apart from the tensile strength, that the chemical composition must be specified.

I have no doubt in my own mind that good piston rings can be obtained outside this specification, but no evidence was offered, nor have I personally seen any evidence, of a regular product complying with the various requirements laid down in the specification (*i.e.*, so far as sand castings are concerned). Immediately such evidence can be produced and laid before the official bodies I am sure it will be given full consideration. It is in this connection that the British Foundrymen's Association can be of inestimable service, and for this reason the above-mentioned movement has my whole-hearted support.

Your remarks concerning the texture of cast iron are very true, but I would ask how uniformity in this respect is to be controlled in a specification.

You also state that "Irons of distinctly different general physical properties may give closely related tensile test results; but not so the transverse test." I venture to suggest that this statement is still a matter of opinion, and that there is no evidence whatever to show that the general physical properties in the shape of resistance to wear, resistance to heat, machinability, and even elasticity and resilience are in any way more related to the transverse test than to the tensile test. This is a matter for research, as is also the whole question of the transverse test.

I personally, as one deeply interested for a good many years in all matters concerning cast iron and its progress and improvement, shall be very pleased to see the whole of these problems taken up by the British Foundrymen's Association. In future years the position of cast iron will undoubtedly be more seriously challenged than hitherto, particularly in its application to internal-combustion engines. It is therefore the duty of the British Foundrymen's Association which has, so to speak, taken cast iron unto itself, to do all that lies in its power for the improvement of cast iron.

Yours, etc.,
J. E. HURST.

Hadfield.
May 13, 1919.

Scarcity of Foundry Apprentices.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—It is with great interest that I have from time to time these last two years read the articles and different opinions written and expressed in your columns in regard to the scarcity of good foundry apprentices. One must admit that the opinions expressed have some bearing on the problem; but, at the same time, as a moulder, I often wonder whether they really get at the real cause which leads to the exodus of the good and educated lad from the moulding shop after a short period therein. After reading some of the articles I sometimes think that the writers are altogether out of touch with the most forcible causes which drive the sensible lad into the machine shop.

To point out some of the drawbacks of the foundry in attracting good lads, I will begin with the entry of a lad into the shop. In a good many shops his first job is straightening sprigs and irons; from that job he moves up to riddling sand for the moulder and skimming the metal at casting-time; his next move is, perhaps, to be handy labourer for one, two or more men engaged on some big job. This exploitation of his labour generally goes on for some time, whilst the unsympathetic foreman does not seem to care so long as the lad is fool enough to keep doing it.

When the lad is at last given a job it is generally with the remark of "Make one," or "Some off that," at which he is left to his own resources with nobody in particular to tutor or watch over him. The consequence is he gets "fed up" with running first to one moulder and then to another to ask "Is this right?" "Is that right?" and "What shall I do next?" From this point he begins to think and watch, and what must the sensible lad's thoughts be when he looks around and sees moulders—some digging, some ramming, and some scraping and rooting all over the shop to find necessary tackle for their job—tackle which ought to be in the shop, but which from 50 per cent. of the foundries is always missing? Then, again, at casting-time what does he think when he sees men with grime and sweat dropping off at their chin-ends, vests and shirts like dishcloths, and in this state to be turned out into the street when the hooter goes?

Contrast these scenes and conditions of the foundry with those he sees in the machine shop. In the first place he does't see a shop full of smoke and dust, a scrap heap here and another there, and one or two somewhere else, and perhaps a pile or two of disused boxes. What he does see is not men wielding spades, ramming their brains out, or carrying metal, sweating themselves to death. He sees none of these things in the machine shop. Far from it. Nor does the machine shop require of him the same amount of skill and foresight that the moulding shop does.

Then who can blame the lad if he compares the two shops and also the wages of the two tradesmen, and decides to leave the foundry for the machine shop? The sensible lad does not fail to realise that for the paltry difference in the two rates of pay the machine shop is the better, cleaner, healthier and easier.

Hence the declining number of proficient moulders; for only the unintelligent lads remain in the foundry, and if they have not the intelligence to see which is the easier trade (with only one or two shillings difference in wages) they have not the intelligence to make good moulders.

Yours, etc.,
J. HOWCROFT.

Bolton.

The Foundry from an Engineer's Point of View.*

By A. E. Bush, Lieut.R.A.F.

The author's object is to indicate to the foundrymen the direction in which they might develop in order to render better service to the engineer. If we compare the state of the art of founding as it exists to-day, with that which existed, say, twenty or thirty years ago, it becomes obvious that great strides have been made in the direction of increased production of superior quality. Much of the advance is due to a greater appreciation of the advantages of the "open door," both literally and by the medium of the interchange of ideas, through the scientific and trade societies and Press. Nevertheless, considerable reluctance to impart information is still displayed by some of those holding responsible positions in the industrial world. I appeal to both foundrymen and and engineers for a greater interchange of ideas and information. Secretiveness inevitably means stagnation, but publicity means progress.

Practically all the advance which has been made in modern foundry practice has occurred since 1880, and the advance has taken place simultaneously, and more or less independently, in England, the United States of America and Germany. During this period has occurred the development of modern foundry machinery, the study of the properties of foundry materials, and in the more enlightened foundries, the classification of pig-irons and castings by their analysis instead of purely by the appearance of their fractures. These changes have not occurred without entailing a vast amount of labour on the part of those earnest and unselfish men in the trade, whose names are to-day household names on both sides of the Atlantic.

To-day we have an added incentive to progress in the goad of competition. Present-day foundries are being forced into quantity production with all its specialised processes and plant, but much yet remains to be done before we can say with any degree of truth that the average British foundry is run on scientific lines.

I now propose to consider how far the present products of the foundry fulfil the needs of the engineer, but I must ask you to remember that I am speaking from a somewhat biassed and personal standpoint, and that in all probability, my views do not coincide with those of other engineers pr sent. The subject may be dealt with under the lowing heads:—

(a) The production of sound castings of correct size and shape.
(b) The production of homogeneous castings of normal quality and of uniform properties.
(c) The production of castings having special properties.

Considering the first classification, there are few engineers here this evening who could not give instances in their experience of apparently simple castings which were not sound and free from draws, blowholes, or other defects. Numerous other examples could be given of castings which were not correct to size or shape. Very often the faults of such defective castings appear to the engineer to be due to a lack of that manipulative skill which every self-respecting moulder's apprentice should aspire to possess; that is to say, faults due to incompetence or carelessness on the part of the moulder or coremaker. In some cases investigation does seem to indicate that the faults complained of are due to neglect of well-known technological precautions, some obvious, others less obvious, yet thoroughly known and understood. Such defects are, for instance, those due to ill-placed runners, feeders, gates and risers, insufficient venting, incorrect ramming and slovenly pouring.

On the other hand, many of the apparently simple pieces give the foundry a vast amount of trouble which might be much reduced if the designers made a practice of calling into consultation the patternmaker and foundryman before finally settling on the details of his design. One might consider the numerous examples which occur of castings very appreciably over size and weight. These may be due to the practical impossibility of producing pieces of the thickness specified on the drawing, or, on the other hand, they may be due to the very common lack of appreciation of the fact that the engineer does really intend his drawings to be worked to in all respects. The patternmaker leaves his pattern a little oversize in order to ensure the casting being thick enough, and the moulder takes care to rap it well to ensure it having a clean draw, with the inevitable result that the engineer finds himself with a casting very appreciably over weight and size. In these days of weight saving this is a serious defect. In either case nothing but good could have resulted from consultations between the parties concerned before the drawings were finally fixed.

Although admitted that in many cases the engineer is to blame for not having consulted the foundry before settling the details of his design, I do suggest to the representatives of the foundries that, in most cases in which trouble is experienced through bad design, the adoption of one or more of the various precautionary measures which the founder has at his disposal, would largely prevent the production of scrap castings. There are other cases in which the defective castings are due to trouble relative to the melting of the metal. Metallurgical science has made vast strides in the last 20 years, as is recorded in the proceedings of the various Institutes, but it does not appear that the founder has taken full advantage of the information thus made available. This does not apply to all, but in the majority of cases too little attention is paid to the principles underlying the metal-melting operations and the result is seen in many cases in the high percentage of wasters turned out. Metal melting is a highly-skilled operation, and should be treated as such under the supervision of a trained metallurgist who is familiar with the purpose for which the castings are required. Many of the troubles associated with castings having thick and thin sections, and with castings incorrect in dimensions, due to peculiar contraction changes, would be obviated if the metal melting and mixing operations were carried out on scientific lines, and also if a closer connection existed between the various branches of the foundry and the patternmaker.

* Read before Joint Meeting of the British Foundrymen's Association and the Coventry Engineering Society.

Let us now consider the production of homogeneous castings of normal quality and of uniform properties. Here one feels tempted to say that such castings are very rarely made. No doubt this is to a large extent due to the faulty design of the pieces, and by calling the foundry expert into consultation before the design was finally settled, much could have been done towards eliminating the defects which only too frequently exists. On the other hand, there remain many instances in which founders have not exercised those resources of their art such as suitable risers, feeders, gates and chills, in order to bring about the desired result. In other instances, too, the venting, ramming, and pouring are at fault. Over and above all this there exist the inherent properties of the metals cast, by reason of which the attainment of complete success is impossible; but, by the exercise of care in the selection of the mixture, and by suitable pouring temperatures, it should be possible to control the result to a larger extent than usually occurs in ordinary foundry practice.

We now come to the production of castings having special properties. With regard to these there appears to exist in the ordinary foundry a lamentable lack of appreciation of the needs of the engineer. No doubt the engineer himself is largely to blame, in that he does not state his requirements in a sufficiently definite manner; but, with a few exceptions, the average foundry appears to be absolutely incapable of working to a definite specification—a very sweeping assertion to make.

In attempting to find out why the average foundry is incapable of working to specification, one is forced to the conclusion that in the majority of cases it is due to a lack of knowledge of the properties of the metals used. In how many of the average foundries of this country do we find a capable metallurgist? Yet, surely, it is impossible to expect to advance with the times without a thorough knowledge of the scientific principles underlying the great bulk of foundry operations.

During this war an attempt has been made by the Branch Technical Department of the Aircraft Production of the Ministry of Munitions to get the foundries to work to definite material specifications; but, while one records with pleasure the whole-hearted co-operation of certain foundries, there is no doubt that in most cases the attempt was resisted by the foundries concerned. The founder did not appreciate that the more closely he fulfilled the requirements of his customers, the more would they entrust him with their requirements in the future, and in fairness I must say that in many cases the engineers also failed to realise the importance of definitely specifying their requirements.

Let me here made it perfectly clear that I am not advocating the employment of the theoretical man to the exclusion of the practical man. Both are required, and it is essential that each be expert in his own department; they should be trained to work together, the one supplying what the other lacks.

The introduction of moulding machines and other labour-saving appliances in the foundry has tended to lower the standard of the skilled moulder employed. This is not as it should be. Without the highly-skilled moulder the modern foundry manager cannot hope to turn out a high percentage of good work. Similarly, the tendency of the blast furnaces to supply pig-iron to a fairly close analysis does not do away with the need for the highly-skilled metal expert, backed up by an efficient physical and chemical laboratory.

Summing up the results of our investigations into the manner in which the present production of the foundries fulfil or fall short of the requirements of the modern engineer, we find that: (a) Accurate castings are not generally procurable; (b) sound and uniform castings are difficult to obtain; and (c) castings having definite physical properties can only be purchased from a very few foundries. We have further found that the engineer himself is somewhat to blame owing to his failure to consult the foundry experts before completing the details of his designs, and his failure to definitely specify the properties which he desires his castings to possess. What, then, can be done to improve the present state of affairs, in order that foundry products may more nearly fulfil the engineer's requirements? The faults may be arranged in the following classes:—(a) Lack of manipulative and technological skill in the moulding operations; (b) lack of skill in the metal mixing, melting, and pouring operations; (c) lack of co-operation with the engineer. We will briefly consider these in this order.

Competition has forced foundry proprietors to instal labour-saving devices of various kinds, such as moulding and core-making machines, and has further compelled them to go in for bulk production of specialised products. The result of this has been that many foundry proprietors employ a large proportion of semi-skilled men, this being rendered possible by the automatic nature of the machines in question and the uniformity in the type of product. Provided that a sufficient number of highly-skilled moulders are employed as charge-hands or under foremen, to supervise the semi-skilled men, no great objection can be raised to this procedure. In many cases, however, the management does not appreciate that, while the routine operations are simplified by labour-saving devices, the difficulties attaching to the principle of founding are just as numerous and difficult as ever, and call for just the same amount of skill and experience in order to avoid large percentages of scrap. In consequence, they do not provide the skilled men, nor do they take any steps to train their young labour. In how many of our large foundries is there in existence a comprehensive scheme of apprenticeship? Further, what provisions are made by our educational authorities for imparting the principles underlying foundry practice to the moulder's apprentice or improver?

The remedy then for the production of faulty castings due to lack of skill on the part of the moulder is the adequate provision of skilled supervision, coupled with a comprehensive scheme of technological education for the young moulder or apprentice.

The next point to consider is the lack of skill in the metallurgical operations. This can only be remedied by appreciating the fact that metallurgical operations can only be satisfactorily carried out when a skilled technical staff is provided, and when that staff is adequately supplied with the necessary equipment. This applies to both foundry and laboratory. It is useless to attempt to run a modern foundry without a metallurgical laboratory, and to try to do without is just as

sensible a proceeding as to attempt to run an engineering works without an engineering department. The attention of the Education Authorities might here be called to the lack of provision for the necessary technical training of the young metallurgist.

We now come to the lack of co-operation between the founder and the engineer. This is a matter which is largely in the hands of the latter. The absence of any comprehensive scheme of technical education prevents the young draughtsman getting that insight into foundry practice which he should possess, and it is, therefore, all the more necessary that the foundry should be consulted in all possible cases. It should, however, be the aim of every draughstman to avoid calling for sharp junctions, rapid changes of section, unsupported cores, and other such fruitful causes of defective castings.

Having now very briefly reviewed the present state of the art, let us consider what is the direction in which the science and art of founding should develop in order to meet the requirements of the future. The present tendency in design is towards the elimination of all superfluous weight, and there is little doubt but that this tendency will remain just as marked in the future. The development of aerial transport and the replacement of horse transport by the motor lorry are indications of this, or perhaps I should say, they represent the accomplishment of the first steps in this phase of engineering development.

If the products of the foundry are to be used to any large extent in the designs of the engineer of the future, it will be necessary for the foundry to produce castings in accordance with definite physical specifications. That these specifications will call for higher physical values than those now produced by the average iron foundry is certain. Scientific foundry control will be essential in order to produce castings to close physical specifications, and as these specifications will call for high physical properties it will be necessary to study the relation of the physical and chemical properties of the metals used.

The specification of high physical properties for his castings by the engineer will in all probability be accompanied by a chemical specification, as is now becoming usual in the case of steels called for by progressive firms. Thus, the foundryman will have to take the necessary steps to ensure that the physical properties which are possible of attainment with a specified chemical composition, are in fact obtained. This means that the founder must study the physico-chemical condition of his metal as revealed by the microscope and testing machine, and the influence which the melting, pouring and cooling operations have had upon these conditions.

Close attention to the melting, pouring and cooling operations will be essential in order to obtain the physico-chemical conditions necessary for the attainment of the physical values specified by the engineer. In order to make use of the higher physical properties certain to be specified, it will be essential that the castings be so well made as to be free from blowholes, draws, and other defects, in order that the finished casting may develop its full strength in all parts, and thus allow of the greatest possible saving in weight.

The question of the price of the finished production will be of vital importance in the future, and, therefore, the engineer will wish to eliminate all needless machining. This will only be possible of the founder produces castings correct to size and shape and having a fine finish. This indicates the desirability for the use of an alternative material for the moulds from that at present employed, which will be less likely to be deformed, and, as the quantity of pieces required will in all probability be large, and prices will be keen, we may require to consider the question of metal or other permanent moulds, and our fourth prediction may be:—Castings correct to size and shape, having a fine finish and having a low cost will be required. Such castings will be preferably produced by mean of suitable permanent moulds.

Owing to the difficulties attaching to the production of sound castings at low cost, we may expect to see a great impetus given to methods of casting which permit the use of metals containing high percentages of impurities, such, for example, as the use of the electric furnaces for refining impure metals, or the use of centrifugal casting processes to ensure the impurities being segregated in portions of the casting which are ultimately removed from the finished article.

When one compares the composition of the steels with those of the cast irons, one is struck with the fact that the irons differ chiefly in that they contain higher percentages of the impurities and of graphite, this latter being largely responsible for the easy melting of the iron. May we not, then, regard the cast iron as easily meltable steel, having properties similar to those of a steel of a similar composition, except in so far as those properties are modified by the ill effects of the high percentages of impurities present. From this point of view it would appear to be desirable to aim at the production of irons having a low percentage of impurities, or, having the impurities so distributed as to avoid any deleterious effect on the properties of the metal. This may be regarded as another prediction of the demands of the future engineer. In addition to the general requirements just indicated, one might suggest various special metals for which there will be a certain demand. Such, for example, as special irons for the cylinders and pistons of air-cooled engines. These would require to have the special virtues of ordinary cylinder irons, but with the added feature, that the metal remains stable under high temperature conditions. Those of us who have had experience with air-cooled engines, know how very liable the present types of irons are to high temperature changes. Sometimes the defect shows itself in a decrease in the strength of the metal, and at other time the tendency of the metal to grow. There is here a wide field for development.

I have so far omitted any mention of steel castings. This is not due to any want of appreciation of the suitability of steel castings for many purposes. On the contrary, I am convinced that steel castings will, more or less, completely replace the so-called malleable cast-iron castings for most of the purposes for which the latter metal is now used. I would, however, suggest to those members who have installed, or who propose to instal, plant for the production of steel castings, that they should investigate the possibility of producing a range of steel castings of compositions analogous to those of the various structural steels now in common use. One might also suggest that the possibilities of alloy steel castings might be investigated.

The foregoing remarks bring us to the subject

of heat treatment of castings, in which the foundry metallurgist has an unlimited field for experimental work. The study of the heat treatment of the steels is still in its infancy, while that of casting is practically non-existent. I have no doubt but that the requirements of the future will compel more attention to be paid to this subject, and I feel sure that such study will well repay for the time spent. The remarks which have so far been made, particularly referring to cast iron, may in general be taken as applying to all cast metals, and I may perhaps be forgiven if I now refer very briefly to light alloys. As has already been stated, the tendency of design in the future will be towards weight saving, and the engineer looks with longing eyes to the light alloys. On numerous occasions we have had our hopes raised by the announcements in the press of the discovery of a wonderful metal, which has the strength of alloy steel combined with the lightness of aluminium, but we are still awaiting its arrival. May one then be excused for again drawing the attention of the foundry trades to the field which exists for the employment of light alloys, and for predicting that the engineer of the future will specify its use for many pieces which are at present made in cast iron or other heavy alloys.

The use of light alloy castings will in many instances be limited by its unsuitability to withstand abrasive action, and we may therefore reasonably expect that the sphere of usefulness of this material would be very much enlarged by the evolution of a really satisfactory method of "casting in" suitable bearing metals, or by some process of improving the resistance to wear of the light alloy itself.

The development of die casting methods may be expected in the near future, and this may greatly increase the usefulness of the light alloys, as also many other methods of consolidating the material, such as subsequent stamping or hammering operations.

Summarising our predictions of the requirements of the future engineer, we find these to be:—

(a) Castings produced to close physical specifications.

(b) Castings of high physical properties .

(c) Castings sound and free from defects in all parts.

(d) Castings correct to size and shape, and having a fine surface finish, preferably produced in permanent moulds.

(e) Castings produced at low cast by refining processes which produce good castings from cheap raw material.

(f) Castings having the properties of the steels by so arranging the casting conditions that the impurities are rendered inert or non-existent.

(g) Castings produced in light alloys having strength and other properties approximating to those of steel.

(h) Castings produced in light alloys, but with bearing or other surfaces possessing special properties suitable to the needs of the design, obtained by "casting in," chilling or local hammering.

(i) Castings produced by die casting processes close to size and order to eliminate subsequent machine work.

(j) Castings having special properties for special purposes.

In considering the future needs of the engineer. I have purposely avoided discussing the technological details of foundry development as being outside the scope of the present subject; but there is remains to be done before the products of the foundry of to-day would fulfil the requirements of the future. When one considers the variations which exist in the properties at different portions of such a simple casting as, say, a piston ring pot, it is obvious that an enormous amount of development work remains to be done in the domain of practical foundry technology. There is also need for the standardisation of test pieces and methods of mechanical testing, and for the standardisation of methods of sampling for chemical analysis. The various methods at present in use are far too diverse to afford any reliable comparisons to be made. It is also essential to the better understanding of the properties of the materials used that the variety of tests employed should be as wide as possible, but in each case the conditions of the tests should be strictly recorded.

Having now suggested the line of development which may be necessary in the future, it only remains for me to state that the requirements of the present can be best met by adequate modern foundry equipment; the employment of a sufficient number of skilled foundrymen as charge-hands and foremen; the provision of a skilled technical staff backed up by an adequately equipped physical and chemical laboratory; the institution of a comprehensive system for close co-operation with the engineers and designers to the mutual benefit of both; and the training of apprentices. The latter should be carried out in conjunction with a suitable course of technical and technological education which the local Education Authorities should provide in collaboration with the manufacturers.

Discussion.

Mr. Williams said he thought the best comment perhaps would be to give some particulars of his experience in connection with the British Chuck and Piston Ring Company, Limited. The firm made piston rings, and specialised entirely in that branch of manufacture. The foundry confined themselves to the manufacture of piston-rings, pot castings and piston castings for internal combustion engines. From his experience he felt convinced that foundries which were connected with an engineering shop, in the same way as obtained at his firm could do a lot in the direction of specialisation, and in that way greatly improve their products. It was entirely due to the fact that they were specialists that they were able to treat their foundry as they did. For example, an excellent feeling existed between the foundry department and the machine-shop department, and they were able to come into very close contact in dealing with each other's needs. Their foundry enjoyed many advantages which, he felt sure, were not possessed by many other foundries. The foundry manager was able to go into the drawing office and lay down the drawing or design for his own pattern. He had his own tool room in which he could make that pattern. Then he had his own standardised methods of placing the runners of those patterns duly recorded on blue prints. His moulding machines were attended to periodically by skilled engineers in the machine-shop tool room. The laboratory was connected not only with the foundry, but also dealt with problems from the point of view of the

machine shop. Those were a few of the advantages naturally derived from close and friendly co-operation between the two departments.

With regard to difficulties in castings, there were certain difficulties quite impossible to avoid, even with the highest skill and technical knowledge. Just as there must be a certain percentage of scrap produced in the machine-shop during the various operations, similarly a certain percentage of scrap was unavoidable even in the best organised foundry. Mr. Williams agreed that there was necessity for greater attention to be paid to the technical side by the foundryman, but there was also the same necessity for attention to technical matters by the engineer. He felt sure, for instance, that theirs was not the only firm who were occasionally asked to make castings to specifications which were unsuitable for the job in hand. The remedy for such misunderstandings as this lay in closer contact and closer co-operation between foundryman and engineer than had obtained in the past.

Mr. E. H. Broughall remarked that Lieut. Bush had suggested that moulders were careless in fixing runners and risers. In this connection it must not be assumed that a moulder can carry out his operations as easily as the machine man. There were many cases in which it was impossible to say definitely where the runner or riser should be fixed until a trial casting had been made. With regard to foundrymen refusing to work on specifications laid down by the engineers, he believed the Chairman had some experience in this direction, and it was a fact that foundrymen had during the war been asked to work to ridiculous specifications laid down by certain Government Departments. He could assure Lieut. Bush that while they wanted the engineer's co-operation, they were not agreeable to be dictated to by engineers who understood very little of foundry work. The lecturer gave one the impression that it was difficult to get British foundrymen to produce good castings. He thought that they had had a fine example that afternoon of what British foundrymen could do as they passed through the works of the Siddeley-Deasy Company, where hundreds of difficult castings were to be seen, and he would ask Lieut. Bush to give the foundrymen their share of the credit for the production of the present aeroplane engines. The lecturer was misinformed as to the means provided for educating foundry apprentices. Although it was to be regretted that such means were altogether inadequate in Coventry, there were several towns in which excellent opportunities for boys to be taught both the technical and practical side of foundry work. With regard to the question of test bars, foundrymen had had this question under discussion repeatedly, and were doing whatever they could to get this matter placed on a proper basis. The present requirements as to test bars were altogether wrong, and a short time ago the Birmingham Branch Council had made a request for a thorough investigation to be made on this subject.

Mr. Ashmore said the lecturer suggested that the cost of castings would be reduced considerably if the method of moulding was changed, and he suggested that the taking up of permanent moulds might effect that change. But he (the speaker) did not see how the cost of castings would be appreciably reduced by permanent moulds, because such moulds would require an expensive staff to maintain their upkeep, and this would naturally have its effect upon the general cost. Viewing the matter from the point of view of the finished article, as well as from the engineer's standpoint, it was not uncommon for a casting which initially cost 3d. to have cost anything up to £3 after going through the engineer's shop.

Mr. Flavell recalled that in his younger days a youth had to spend a certain time in the foundry, a further period in the pattern shop, and other periods in the fitting shop, finishing up in the drawing office. The ordinary draughtsman of the present time commenced as a boy from school and went straight into the drawing office and began his tracing work. He knew practically nothing about the practical side of foundry work. He had had an example that week of the stupid things that were done. There was a steam box required, 4 ft. long by 15 in. wide and 4 in. deep of § thick metal. The order came from a firm which maintained a staff of draughtsmen. It was involved in metal at the top and bottom, ends and side. If the man who made that drawing had any practical knowledge he would have never made it like that because there was no means of getting the core out or getting the air off the casting. If the co-operation desired by the lecturer had not been obtained that was not the fault of the foundryman. He had known instances where practical foreman moulders or foreman patternmakers, with 20 or 30 years' experience, taking a drawing into the office would almost be ridiculed by young draughtsmen of five or six years' experience, who had never had a single year's experience in the foundry. That was the sort of thing that ought to be altered, and it could be altered by the organisation of a proper system of apprenticeship.

Mr. F. E. Shearman, referring to the necessary of bringing the draughtsman, the patternmaker, and the moulder into the closest co-operation with each other, said that in Brimingham classes existed and were so arranged that a boy taking up one subject must also take up the other two. Those classes at present were being conducted during the evening, but they must remember that the times were gone when boys would turn out at six o'clock in the morning and study in the evening. Undoubtedly the conditions were stringent enough under the new system when they commenced work in the foundry at 7.30 or 8 a.m. and continued at work until 5 or 5.30 in the evening, and they could hardly expect a boy to study successully in the technical school in the evening.

The Chairman said the lecturer had, on the whole, given a fairly accurate statement of the present position of the foundry trade; though they might possibly feel that Lieut. Bush had been rather severe in his strictures. With regard to the training of youths, he thought this was perhaps the most important matter that had to be dealt with in the near future. He would take the opportunity of saying that schemes were in preparation locally of a very comprehensive and far-reaching character. The scheme which was being drafted by the factory with which he (the speaker) was connected would include education for the boy in the daytime at the employers' expense. The scheme would also attempt some kind of differentiation of different lads according to their natural aptitude and the industry and intelligence that

was displayed. It would be possible for boys who showed conspicuous merit to qualify for a more advanced course of training, and where it was justified this advanced course might even be extended to include training at a University.

Apart from such schemes which were being developed by individual firms, action was also being taken to assist the local Education Authorities in organising a technical college on modern lines and capable of meeting all the requirements of the district. The Chamber of Commerce was taking an active part in this matter, and there was no doubt local manufacturers would make substantial contributions to enable the Committee to provide the necessary technical training.

LIEUT. BUSH, replying to to the discussion, said that nothing was further from his mind than to belittle the British foundries, which had done most excellent work during the war. He had seen many of their productions, and while they had done well in the past they should still further develop in the future. There was a good deal yet to be done before they had reached perfection, either from the engineering or foundry side. He thought Mr. Ashmore rather missed the point with regard to permanent moulds. He (the lecturer) did not intend to suggest that the cost would be lessened by permanent moulds, but rather that the total cost, including machining, might be lessened by the use of such moulds. He agreed, also, with Mr. Flavell as to the necessity for the more thorough training of draughtsmen. That was one of the difficulties that engineers had to meet and it arose to some extent because their draughtsmen had not received training in foundry work or pattern work.

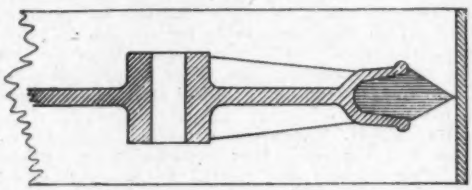
"GERMANY'S ARMOURY." Dr. J. Reichart, shortly before the Armistice, published a book in German, under the title "Germany's Armoury," for home propaganda purposes, from which Sir Robert A. Hadfield has obligingly sent us an abstract and translation for publication. Sir Robert's comment on Chapter V. (War Production) is to the effect that from a technical point of view, this is somewhat disappointing. Manganese ores were short in Germany from the start. Sir Robert thinks that perhaps this accounts for using a steel for helmets which required the 20 operations shown in the book. Seven of them were required for shaping the crown. The German military authorities made a miscalculation of the enormous quantity of material required, and allowed months to lapse before remedying it. A complete change came in 1916, with the Somme battle, as the Allies increasingly bombarded the German positions with a veritable hail of iron. The Hindenburg programme was redoubled, the demand for mines, shell, guns, howitzers, and barbed wire was trebled, and a new committee for controlling raw materials was appointed. Measured on the 1913 basis Germany produced more pig-iron and ingot steel than the Allies in Europe put together. According to Dr. Reichart, without the Lothringen ore region Germany could not have gone to war. The cost of the iron and steel used in one day in the Flanders battles was more than the whole used in the 1870-71 war. Chapter VI. on "Labour," is to allay dissatisfaction in Germany by appealing to patriotism, and painting the conditions of German workmen in glowing colours. We are further told that prisoners have been an indispensable aid in German war industries, and that the average wage of workers in the steel industry in 1913 was £66 per year; some even got £100 per year, but that wages have at least doubled during the war. The statement is also made that 274 firms gave £17,500,000 for welfare work during the war.

Wheel Moulding.

By C. THOMAS.

The sketches show the method adopted for moulding a rope wheel in a two-part box. The pattern is in halves; the top box is first rammed up with one-half the pattern on the joint board. Before turning this over the pattern is fastened in position by means of the lifting screws and wedges. When this is turned over the joint is made to the bottom of the shaded portion.

The other half of the pattern being now in position, the shaded portion is rammed up with a few sprigs or pieces of iron in to stiffen it. After



jointing as shown, the bottom is rammed, and the half-pattern fastened so that when this box is lifted off the half-pattern will come with it. This portion of the mould and the half of the shaded portion are now finished, and the bottom box is replaced. The whole box is turned over and the same process applied to the top. By this means the shaded portion always has a firm seating, and is never removed from the mould. This greatly reduces the liability to damage of this portion of the mould.

ELECTRIC FURNACE v. SMALL CONVERTER FOR SMALL STEEL CASTINGS.—In a Paper read at the recent Boston Convention of the American Foundrymen's Association, Mr. C. R. Messinger, of the Electric Steel Company of Chicago, compared the advantages and disadvantages of the electric furnace and steel converter for small steel castings. He described the working of two single-phase electric furnaces with bottom electrode. The best results were obtained with acid linings. An average of 368 heats per lining has been obtained with a refractory cost of 3.9d. per ton of steel. The electrode cost was 35d. per ton, the power consumption averaging 635 kw.-hrs. per ton. The total costs show a slight margin in favour of the electric furnace, but in the East, where the freight on low-phosphorous pig-iron is much lower, the margin would be in favour of the converter. In the best thirty-day period an average of 9.24 heats per twenty-four hours was obtained, the average melting time being two hours and twenty-five minutes and the average charging time ten minutes. The furnaces were of one ton capacity. The average labour cost was 8s. 9d. per ton of steel melted, including bringing scrap in from the yard and repairs. The consumption of electrodes on a furnace making 2,029 heats in thirteen months was 13,170 lbs., or 5.15 lbs. per ton of steel melted. The present cost of graphite electrodes is about 6½d. per lb. The foregoing furnace was used in pouring very small castings with an average weight of less than 4 lbs.; hence the furnace was not tapped until the metal was very hot and the power was left on longer than would be required in most foundries. A power consumption of 570 kw.-hrs. per ton could easily be attained by greater care in operation. Repairs need not be made oftener than once in six weeks. Numerous classes of scrap can be utilised. Continuous service by the central station is most important.

Pattern Turning.

By Joseph Horner.

"Between Centres" Work.

The fork or prong chuck drives work between centres. It is forced into the end grain of the softer woods with the hammer, while a sawcut is usually made in the end of the hard woods to receive it. Except in pieces of very large diameter, as, say, in those which approach toward the maximum swing of the lathe, the holding and driving power of the fork remains perfect in hard woods during heavy roughing down and finishing. Occasionally the back centre may have to be tightened up slightly in order to take up the slackness of fit which develops between the fork and its recess.

Work which is carried between centres comprises probably quite half the total amount done by patternmakers. Its range is very great, from the flimsiest to the heaviest, and includes both solid and jointed work. Each gives rise to problems peculiar to itself. All long pieces, whether they are light or heavy, must be steadied. The commonest kind of steady has a body keyed to the shears of the lathe bed, fitted with divided bearings, a design suitable for either light or heavy work. Instead of cutting bearing blocks to circular form, vee'd blocks are often used, with the advantage of giving a small range of diameters for each

Fig. 1.

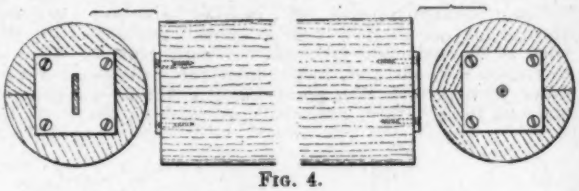


Fig. 4.

Fig. 2.

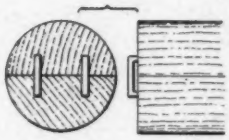


Fig. 5.

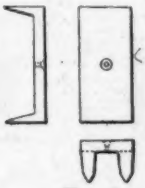


Fig. 6.

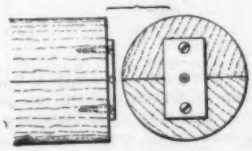


Fig. 3.

Fig. 7.

Fig. 8.

But in large pieces of soft wood the fork will enlarge its location so much as to produce inaccuracy in the turning. The point centre will also penetrate deeply. In such cases the proper method is to use the same centre plates that are employed in turning jointed patterns, and this is often done.

There are a number of the bigger jobs which are driven by a point centre and driver in preference to the fork because the fork is of a size too disproportionately small to the diameter. As a carrier cannot often be put over the end of pattern work, a nail or screw is driven in, or two are set on opposite sides of the centre, to receive the thrust of the driver. Because of the shocks due to the high speed at which wood is turned it is well to tie the end or ends of the driver to the nail with fine wire or string. The driver may be a screwed pin put into a hole in one of the smaller face plates, or it may fit with a hexagonal hole over a shoulder of similar form on the neck of the point centre.

set of vee blocks. But circular blocks can be planed in the joints from time to time to take up wear. The body of the steady remains good for an indefinite period. Although a crude design, if compared with the steadies of the metal turner, it is a perfect appliance for the pattern shop. Each lathe has, or should have, one or two of these.

The portion to which the steady is to afford its support must be turned down with extremely light cuts in order to preserve the long work in its normal state of revolution. If the cutting here is forced the piece will wobble, and when the steady is removed the piece will not be true lengthwise. The diameter of the belt is not necessarily that of its finished diameter. It is better if left slightly larger to be subsequently reduced, the steady being shifted elsewhere. Often in very slender pieces it is not practicable or judicious to turn down the belt at once to the finished size, either because the vibration and sag is too great to permit of it, or because the wood will warp and

spring on the removal of the outer layers of material. In cross-grained crooked fibre this springing will often be considerable in amount.

Having the belt roughed down and left thus by the gouge it is gripped in the steady. Roughing with gouge alone is better than using a chisel, because the gouge can be used more lightly. Moreover, the grooves left by the gouge hold the lubricant which is necessary. A mixture of soft soap and blacklead is the proper lubricant to use.

A difficulty due to turning long pieces is that they warp and spring as the work proceeds. There is an advantage sometimes in roughing out a few days before the turning is completed. It is also often desirable to shift the position of the steady once, or more. The work being sustained by the first setting made, can then be turned down with less hesitation and with more accuracy than if done at the first time before the steady has been introduced.

Long straight pieces of parallel diameter throughout are checked with a chalked straightedge as the reduction proceeds. A good plan is to reduce the ends first, rough down the intermediate portion, and then plane along a flat from one end to the other, and chalk or red-lead the

Fig. 9.

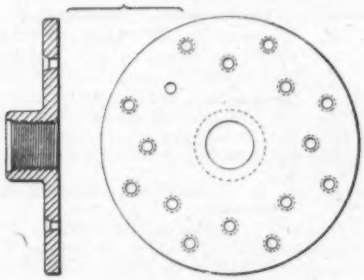


Fig. 10.

Fig. 11.

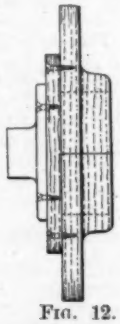


Fig. 12.

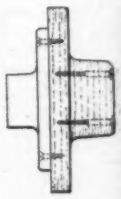


Fig. 13.

flat. Then turning can go on with little risk of getting below size, and without resorting to the calipers until the flat is nearly obliterated. Or belts can be turned at short intervals by calipering, and lengths between turned subsequently. But the obliteration of the flat will not alone indicate accuracy. A straight-edge covering the whole length must be used as a final test of truth. This method is suitable for plain tapered work as well as that which is parallel. Objects which are bellied lengthwise, as in the entasis of columns, are best turned by means of a templet, having its edge cut by the drawing and applied to the work. Another way is to turn shoulders at definite intervals to sizes taken from the drawing, and turn the parts between to curvature by the aid of a short templet, or sometimes by the unassisted eye.

When a lathe is fitted with a slide rest, as in the regular pipe and column shops, the tentative reduction in diameter is avoided, the slide rest taking charge of the tool. But the majority of general shops are without that convenience.

Many difficulties in pattern turning are due to the frequent necessity of jointing, which is a source of weakness, while the rotation tends to open the joints. A long article, say, averaging two or three inches only in diameter, and jointed, has to be dealt with tenderly if accidents or inaccuracies are to be avoided. The steady affords but one help—other points have to be considered. The question arises how to joint, and how to retain the halves closely. The securing of the ends is not, except in the case of very short articles, sufficient to keep the central parts close during revolution. These have to be maintained in close contact either by paper joints, or screws, or iron dogs, each according to circumstances.

For the lightest jobs paper joints are sufficient. Strips of paper are glued in the joint at intervals, Figs. 1 and 2, and the parts are easily separated after the turning has been done. It is still necessary to secure the ends during turning, otherwise the pressure of the lathe centres would probably split the joint open. Then either screws as in Figs. 1 and 2, or centre plates Figs. 3 and 4, or dogs Fig 5, are put in just as though no paper joints were used. Screws alone are commonly employed for the smallest articles, one at each end, and enough extra length is left to receive the screws, the stuff being shouldered down adjacent, Fig. 1. If no paper joints are used, and the work being rather longer than that shown, one or two screws are put in temporarily at intermediate positions, and their holes are filled up afterwards.

In the heavier work, dogs are very conveniently used at intermediate positions, and are shifted as the turning proceeds. Often when a job is dowelled, as it almost invariably is, dogs are used at the ends, Fig. 5, instead of centre plates. But the latter must be employed in heavy work for the reasons just now given in connection with the turning of heavy objects. For small articles the centre plates are often formed like dogs, only they are made wider in order to receive the centres, Fig. 6. For large work the plates are attached with screws or with nails, two or more in number, as in Figs. 3 and 4.

In some cases more than two articles have to be turned at once in a single length of stuff. Where boss sections fit on opposite sides of a web or plate, then a piece of wood of the exact thickness of the plate is fitted between the boss sections, as in Figs. 7 and 8, and all are turned together. The thickness piece is then thrown away, and the boss sections used. Paper joints and screws are more useful in these cases than the plates, because they prevent any tendency of the surfaces to slip.

The turning gouge is used for roughing alone, applied straightforward, and right- and left-handed. Only the final finishing, slight in amount, is given by the chisel. Except in small diameters, say below about 3 in., finish is imparted by the firmer chisels used as scrapes, and the round-nose and allied tools are similarly applied. The side

chisel is employed for finishing small diameters and for shouldering down and cutting off.

Faceplate Work.

Faceplate work, both small and large, is handled in many ways. It is of a very different character in a brass finisher's shop, and in that of a general engineer's, or of a shop making gear wheels. Two kinds of face chucks are used, the smallest with a tapered screw, and small, and medium, and large sizes with screw holes only. Most pattern work is turned on intermediate faceplates of wood, for several reasons. All pieces of large diameter, and all articles which are rechucked, have to be so done, and most of those of small diameters are so turned.

The taper screw chuck, Fig. 9, is used in direct contact with the work, for small articles only, and these chiefly bosses which are turned plank-way of the grain. Pieces which have to be turned long-way of the grain in soft wood cannot be held securely on account of the screw stripping the wood. These must be put in the bell chuck. But the taper screw chuck is used frequently with a wooden faceplate intermediate between it and the piece to be turned. Much small work is thus dealt with, being held and done by the same methods which are adopted in that carried on larger faceplates, to be noted directly. The advantage of the taper screw chucks in this respect is that they are of small diameters, and it is often necessary to use chucks smaller than the work turned on them, as when the hinder part of a piece has to be got at, to avoid rechucking. The chuck is often provided with three holes for screws, which afford additional security in holding a wooden faceplate or a piece of work.

After this, the smallest of faceplates, come the plain ones, Fig. 10, made in brass or iron, which differ from each other only in size, of which every lathe has an equipment of three or four, smaller and larger. They are screwed directly to the work, Fig. 11, or to an intermediate faceplate, Fig. 12. In the latter case the piece of work may be held with screws passing through both plate and chuck; or, if of large diameter, with screws that go through the wooden chuck only beyond the diameter of the metal plate, as in Fig. 12. Or instead screws may be put in from the front as in Fig. 13, or other methods of holding are adopted according to the character of the turning being done.

Quantities of thin bosses and circular facings are turned while held with a couple of loose nails only, Fig. 14, on a wooden faceplate. The nails stand out ¼ in. or so, and are withdrawn readily by the pincers after turning. These bosses are frequently not faced, the board from which they are cut having been thicknessed first. Only the edge then has to be turned. If the stuff is not thicknessed first, rails may still be used and thicknessing done close to the nails, as in Fig. 14, and the central part will be reduced with a plane after the bosses have been put in position on their pattern.

Nails or screws are frequently used when turning rings. They are put in through the central disc left by the cutting-off of the ring. Thus a pump-ring like Fig. 15, typical of many others—turned in solid mahogany—would be held by nails as shown, or screws, or sometimes by a paper joint at the centre, and the ring when finished would be parted off with a chisel presented as in the Fig. Valve seatings, if shallow, might be turned in the same way, or alternatively in the bell chuck.

In the selection of methods, much depends on the thickness and weight of the work. Very large pieces cannot be held securely with nails; then screws are put in either from back or front, whichever happens to be more convenient. Figs. 16 to 18 show three common jobs as alternatives. The illustrations are of two beadings and a flange. It is usual to prepare work of this kind on a faceplate ready to slip into grooves that are turned in the body of a column or a pipe pattern. The column beading in Fig. 16 may be attached with screws in the central area to the faceplate, and be turned convex on the back and front, and then parted off as indicated. The lathe is ran slowly as the parting cut approaches completion, to prevent the beading from flying off, or it may be stopped and the last 1-16in. cut through with a saw. In Fig. 17 a flange is being turned with a small hole. Screws are put through the wooden faceplate into the flange, and the central hole is bored out, leaving the flange attached to the plate. In Fig. 18 a column moulding is shown with the screws put through the wooden chuck from the back.

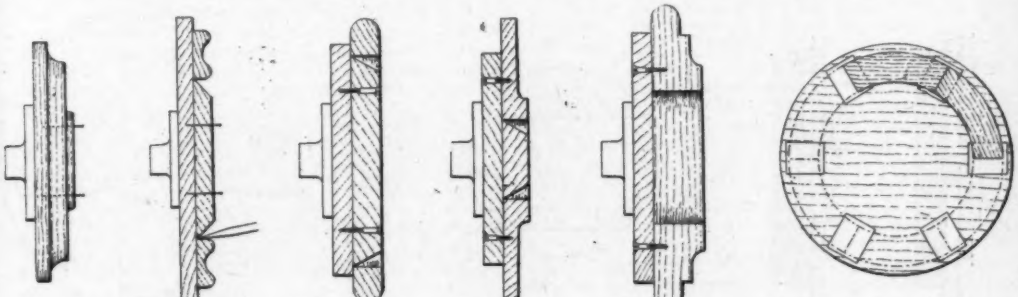


FIG. 14. FIG. 15. FIG. 16. FIG. 17. FIG. 18. FIG. 19.

In these examples it will be seen that the wooden faceplates are smaller than the work which is held on them. This is very often the case, and is frequently essential. It is so in Figs. 16 and 18, in order to permit of turning the hinder portions of the convex edges. And there is no advantage in having a faceplate larger than is necessary to afford support to the piece being turned. If much larger, it is in the turner's way. Neither must it be less in diameter than is required. If there is a hole,

for example, in a job the plate must be considerably larger than that. Hence a goodly number of wooden chucks are wanted, and they are changed about on the iron plates as required for different jobs.

A large class of work is held with a paper joint and nothing else. A disc of paper will hold any pieces securely up to 6 in. or 8 in. diameter. This is not adopted for ordinary bosses and similar work, because a few hours must elapse in order to allow the glue to dry, but it is employed largely for thin work, and for pieces which have to be turned into irregular shapes, where nails or screws would come in the way, and for rings.

One of the most frequent utilisations of the paper joint is that of building up rims of pattern wheels. The first course of segments is glued to the faceplate with paper joints, not all over, but only for an inch or two on each side of the end joints. Fig. 19 shows the appearance of a faceplate having paper glued on in readiness for the segments, with two of the latter glued on, and the circles and joints marked for the set. Sometimes, in large and heavy work, a couple of screws are put into each segment from the back of the plate for extra security, but this is rarely necessary unless the depth of segments to be built up is considerable. Properly jointed and glued the paper holds securely, while, when the work is turned, the joint can be broken through the paper by inserting a chisel and lifting the work off by leverage.

Re-chucking occupies a large place in pattern work, though it is usually avoided when practicable. But when opposite sides of a pattern have to be recessed or turned other than plane, re-chucking is essential; and when possible, the frictional grip of the work and plate is taken advantage of to avoid the use of screws. But such surfaces must be parallel or nearly so, and the length of stuff projecting must be moderate only. The result is that there is not much pattern construction outside of small brass work which can be held frictionally. Screws, or sometimes paper joints in flimsy pieces, are usually necessary. Bevel and spur wheel patterns may be chucked by a central hole, which hole serves afterwards to receive the stud of a boss or print. A large ring would be chucked by the inner diameter. In each case screws are necessary to secure the work.

As plates increase in diameter, economy requires that they shall be retained in service as long as possible. Rechucking in the largest plates is therefore often done on independent blocks, to avoid turning down the plates themselves. These are screwed through the face or back, and recessed outside or inside as required, and the screws are put through the back of the body and through the blocks into the work. Figs. 20 and 21 illustrate the chucking and rechucking of a spur gear ring on blocks attached to a faceplate.

As patterns increase in size the faceplates can no longer be plain discs of wood, which are only suitable for diameters up to about 14 in. or 15 in. Larger plates are differently made. The simplest are battened, Fig. 22, which make useful plates, or stuff is crossed in two thicknesses without battens. Though this avoids the objection of the battens standing out, and retains accuracy, the numerous screws are a nuisance when the thickness becomes reduced. The largest plates are built with segments on a cross, Fig. 23, which leaves a large central area unoccupied with plate. The cross remains permanent, and the segments are renewed as they become worked down.

The flat firmer chisel occupies an important place in pattern turning, because of the large amount of faceplate work involved. Other tools derived from this are also in constant request, as the side tools, right- and left-hand, the diamond points, and the round-nosed tools.

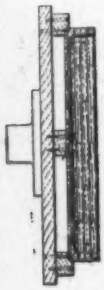


FIG. 20.

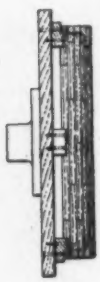


FIG. 21.

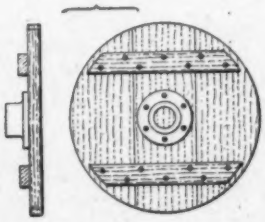


FIG. 22.

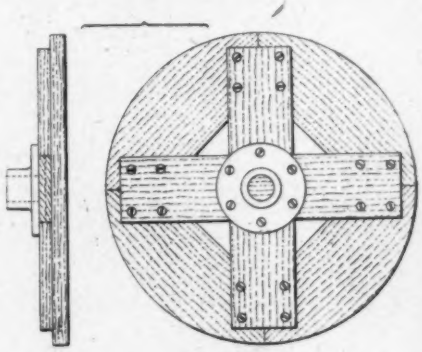


FIG. 23.

THE LEDEBUR METHOD FOR DETERMINING OXYGEN IN IRON AND STEEL.—Messrs. J. R. Cain and E. Pettijohn, in a "Technologic Paper" recently issued by the U.S. Bureau of Standards, show that (1) the Ledebur method requires extraordinary precautions to obtain reliable results. The errors described by the authors undoubtedly affect in greater or less degree nearly all results by this method that have been described in the literature, and if these are approximately correct it is because of compensation errors. (2) The Ledebur method as described determines with certainty only oxide of iron, oxides of manganese above Mn, and the oxides of nickel, copper, and tungsten if the latter three ever exist in steel. In turn such oxides are determined correctly only in case they exist in the metal uncombined as silicates which probably seldom happens. (3) Ledebur oxygen determinations show no distinguishing features for acid Bessemer, basic or acid open-hearth, duplex, electric furnace or crucible steel. (4) Ledebur oxygen determinations show no differences in steels deoxidised with a variety of deoxidisers.

Visit of American Foundrymen's President.

RECEPTION BY BRITISH FOUNDRYMEN.

Following so closely upon the termination of the war, the visit of the President of the American Foundrymen's Association, Mr. A. O. Backert, was specially acceptable to his British confrères, as furnishing an opportunity to show to the visitor the extreme cordiality existing between the two great English-speaking nations, as well as to testify to the strong feeling of comradeship which exists between British and American foundrymen. Immediately the pending visit of Mr. Backert was made known the matter was taken up with the utmost heartiness, and a series of receptions, dinners, and meetings arranged in honour of the visitor, and Mr. Backert was kept busy several days receiving the honours from his various hosts.

He arrived in England on Saturday, April 18, and after staying several days in London, visited Sheffield on April 28, where he was received by Mr. T. H. Firth, the President of the British Foundrymen's Association, and nearly two days were spent in visiting the Wicker Iron Works, of which Mr. Firth is the principal, the Hadfield Steel Foundry, under the control of Sir Robert Hadfield, the works of Messrs. Edgar Allen, and the establishment of Messrs Steel, Peech & Tozer. From Sheffield he travelled to Birmingham, where Mr. Frank Somers (Walter Somers & Sons, Limited) was in readiness to receive him, and during his stay in Birmingham he was the guest of Mr. Somers at the Leasowes, Halesowen. Subsequently, he was entertained by the Coventry Branch of the British Foundrymen's Association, by the general body of the B.F.A. at Sheffield, and finally at a joint meeting of the Birmingham Branch of the B.F.A., the Staffordshire Iron and Steel Institute, the Birmingham Metallurgical Society, and the Birmingham section of the Institute of Metals. Details of the various functions are given below.

THE COVENTRY VISIT.

The Coventry visit took place on Wednesday, April 30, when Mr. Backert was received on his arrival at the city by Mr. Andrew Harley, the President of the Coventry Branch, Mr. Oscar Harmer, Director and General Manager of Alfred Herbert, Limited, Mr. E. H. Broughall, Works Manager, and other gentlemen. A visit was paid to the works of Alfred Herbert, Limited, machine tool makers, where, in honour of the visitor, the Stars and Stripes flag was gaily displayed at the entrance to the works, a compliment which Mr. Backert very warmly appreciated. Under the guidance of Mr. Harmer and Mr. Broughall a tour was made of the works, which have been very largely extended during the war, and a detailed examination was made of the various up-to-date apliances which have been introduced, not merely with the object of increasing production, but of securing the very highest possible quality in the various mechanical productions in which the firm specialise. During the war the entire works was reorganised, with the result that while the area was extended by about one-fourth, the output was quadrupled.

Leaving the works of Messrs, Herbert, a visit was made to the firm of Rowland Hill & Company, whose products are almost entirely in aluminium metal, and some complex castings, chiefly for aeroplane work, were shown, including a number of very large crank cases. The visitors were received by Mr. Carey Hill and Mr. Percy Hill, the firm's directors. About 150 are employed, and in this case also, by reorganisation, a greatly increased output of the highest value to the Aircraft Department was secured.

The party were entertained to lunch by Mr. Oscar Harmer at the County Club, and the afternoon was mainly spent in a tour of the large Daimler establishment. The shops occupy about 45 acres in extent, and one of the largest is a quarter of a mile long. About 7,000 men are employed, of whom 500 are in the foundry department, and there are four Bessemer converters dealing with the steel, each of a capacity of 12 cwt., and four cupolas for melting cast iron. A small electric furnace has been in operation for some time, but this has been superseded by a Greaves-Etchell electric furnace of two-ton capacity, which will shortly be put into operation. In the transformer house, current is received at 2,000 volts, which is transformed for general purposes into 200 volts, and into 60 or 90 volts for the electric furnace. The Daimler has the distinction of having made the first steel links used in the "tanks," which played such an important part in the war, and an enormous output of this kind of work was made. During the war the production consisted very largely of munition and aircraft productions, but these are gradually being replaced by motor constructions for which, of course, the works were originally laid out. Some time was spent in the very fine laboratory, which has lately superseded the much smaller departments of the kind, and which has a large number of testing machines for the carrying out of every recognised description of mechanical tests. Of these departments, Mr. W. H. Pickin is in charge. He has ten assistants in the mechanical laboratory, six in the micro-structure heat-treatment department, with eight workmen solely engaged in the preparation of samples for testing. Many experts consider this laboratory, which comprises 14 separate rooms, equal to any in the United Kingdom.

The visitors were entertained to tea at the works of the British Piston Ring Company, where an inspection was entirely devoted to a new machine for casting piston rings. The casting machine consists of a revolving barrel, the rate of revolution being regulated by the nature of the casting, but it is possible to produce piston rings ranging in size from 4 in. to 30 in. The metal is taken from the pouring furnace by the usual hand conveyor, and poured into a small spout from which, by means of a hand circular tilter operated by a wheel, it is emptied into the revolving barrel in such a way that the molten metal is whirled round the barrel, forming a complete tube. It is possible to withdraw the casting in a few seconds sufficiently cooled and exact to size.

The Dinner.

The complimentary dinner to Mr. Backert took place at the Masonic Hall, and was presided over by Mr. Harry Smith, of the Rover Company, who, with the Daimler Company, were the hosts of the occasion. The following were the guests:—Messrs. A. O. Backert, Henry Smith, E. M. C. Instone,

J. K. Starley, O. Harmer, G. H. Henson, A. Harley, F. H Hurren, E. H. Broughall, A. Craig, R. Buchanan, F. J. Cook, J. R. Handforth, G. Williams, P. J. Dawes, C. B. Pugh, T. Vickers, W. Birkett, R. C. Bullock, G. Roberts, A. T. Linnett, F. H. Lane, E. Whitworth, A. Harrison, W. Jacques, A. Fraser, H. Toplis, A. S. Lancaster, C. C. Hanch, J. C. Percy, A. H. Niblett, Capt. Smith-Clarke, Messrs. T. W. Picken, E. N. Boote, G. Needle, T. G. John, W. Binnie, J. W. Rushforth, T. W. Miles, D. Cartwright, E. Cox, C. Burnett, A. E. McIntosh, D. Sharp, J. Buchanan, A. Stynes, S. Corden, L. Haxby, J. Horton, G. Rollaston, R. C. Mountfort, M. Wild, E. Carey Hill, and A. P. Smith.

The toast of "The King" was duly honoured on the motion of the Chairman.

Mr. Andrew Harley proposed "The American Foundrymen's Association." He assured the visitors that everyone in the Coventry district was very glad indeed to welcome Mr. Backert to Coventry. It was a very unusual thing for the President of the American Foundrymen's Association to visit this country, and probably none of Mr. Backert's predecessors had ever come in an official capacity. At the same time, it was a very happy coincidence that the American President should be visiting this country this year. He was very glad to express the acknowledgments of Englishmen on the valuable help given by Americans towards the successful conclusion of the war. He sincerely hoped that the brotherly feeling which had been created during the war between Englishmen and their American cousins would be perpetuated. Prior to the war the acquaintance of the two nations was not as good as it might have been, but the war had brought them into close co-operation, and everyone desired that it should continue. The American Foundrymen's Association, like the British Foundrymen's Association, was a practical and scientific body, existing mainly for the promotion of technical knowledge and the handling of foundrymen's problems. He did not know any industry in which the call for technical knowledge was greater. To some extent, that sort of training had been neglected during past years, and though great strides had been made in that direction, a good deal of leeway had to be made up before they could take their place side by side with the engineering industry which was so greatly specialised, and which was continually making increasing demands on the foundrymen. No doubt during his visit to England Mr. Backert would form some idea of the great contribution which had been made by foundrymen for the requirements of the war. He believed the American Foundrymen's Association was 24 years old, while the British body was 16. The American body had a membership of 1,300, while the British Association had now a membership of 1,500. He was very proud to tell them that the Coventry Branch, although it had only been established a few weeks, was the largest branch of the B.F.A. The speaker concluded by wishing success to the American Foundrymen's Association.

Mr. A. O. Backert, who had a rousing reception, said he had been completely overwhelmed by the many courtesies, kindnesses, and hospitalities he had received since he came to Coventry. He regarded his reception as a compliment to the American Foundrymen's Association, and as an expression of deep friendship existing between Englishmen and the United States. He hoped the day would come when they could reciprocate in kind. He had been greatly touched by the kind references to his country and by the recognition of the part played by America in the war. At the same time, when he thought of what they might have done, as compared with what they did, it made him feel somewhat heart-sick. They ought to have been in the war the very day the "Lusitania" was sunk. It was quite true they comprised in the United States many nations, and on the day war was declared there were reasons to fear from outward appearances that German propaganda really represented the whole of the people; but it never did anything of that kind, and all along the President had the united nation at his back. It was said by one paper that if they had conscription in America there would be riots, but there never were riots, and not a man hesitated to leave his home and go 3,000 miles to help in the fight. He could assure them that the American people appreciated what was done by England. The only criticism he would offer was that the English people did not let the American people know of the wonderful British achievements in the war. The American people patted themselves on the back last autumn, and were very proud of the fact that they had turned out 1,000 motors, but in Great Britain one single works turned out 500 in a week. Thanks to the British Bureau of Information in New York, he had some idea of the wonderful work done by this country, and something of that work had been eloquently described by a British speaker. He could assure them that the American heart now beat in sympathy with Great Britain, because of the enormous sacrifices that had been made. A short time after the war it had been declared that there was freedom on the seas, but that real freedom had been maintained all along, because the seas were freed from the Hun tyrant by the great British navy. It was the same navy which kept open the lanes for the shipment of soldiers, and if the Huns had driven all the land fighters into the sea he would still have had to reckon with the great British navy, which would have kept him bottled up, and he would have been forced to surrender in the end. He hoped that such a comradeship as existed between the American and the British Foundrymen's Associations would help to strengthen the arch of friendship already existing across the Atlantic and uniting the affection of the two great English-speaking nations. (Applause.)

Mr. A. H. Niblett proposed the toast of "The British Foundrymen's Association, Coventry Branch."

Mr. E. H. Broughall, in responding, said that although the British Foundrymen's Association had been established 15 or 16 years, it was very little known in the district. They meant to look specially after the foundry apprentices, who had been lamentably neglected in the past. The provision to be made for the assistance of young foundrymen was to be the object of a deputation to wait upon the Coventry education authorities. They meant, if possible, to surpass Birmingham in their educational arrangements.

Mr. W. A. Oubridge proposed the toast of "The Daimler and Rover Companies," the hosts of the evening. They were greatly obliged to the companies for their generosity in placing their resources at the disposal of the Branch on this historic occasion.

The toast was responded to by Mr. E. M. C. Instone, for the Daimler Company, and Mr. J. K. Starley, for the Rover Company.

Mr. R. Buchanan proposed the toast of "The City of Coventry." He pointed out that Coventry was a city when Columbus started out to discover the Western Empire. It was a fine example of the assistance rendered to the war by the co-operation and development of the local industries.

The toast was briefly acknowledged by Mr. Oscar Harmer.

The concluding toast was "The Chairman," proposed by Mr. E. Carey Hill, and briefly acknowledged by the Chairman.

General Meeting of Coventry Members.

A general meeting of the members of the Coventry Branch took place in the Masonic Hall immediately after the dinner, presided over by Mr. A. Harley, the Branch President.

In welcoming Mr. Backert, he said that if he had come eight months ago he would have found the whole of the city producing a maximum output of war munitions. While sending its full quota of men to the Army, supplies and munitions of all kinds had been sent in enormous quantities. He did not think there was any city of the acreage of Coventry which produced a greater variety of munitions nor had any city so greatly multiplied its output.

The speaker dwelt in some detail on the educational importance of the Association in its efforts to promote efficiency among workmen, chargehands, foremen, managers, and proprietors. They were seeking efficiency all round in their industry, which was the basic industry of engineering. The continually increasing demands of engineering compelled them to continually improve the quality of their productions. Foundrymen lived in an atmosphere of trouble, but at the same time the responsibility rested upon them of obtaining a regular flow of good material in the engineering shops.

Mr. A. O. Backert, acknowledging the welcome, said he doubted whether any Branch in the United States could muster so representative a gathering, and he sincerely congratulated them on their enterprise. The American coming to Great Britain was usually looked upon with suspicion, as it was supposed that he had come to find out all he could. He quite admitted that he had an axe to grind, in fact, he had several. It would take him six months to grasp the wonderful variety of their industries. The Englishman was said to be slow, but if the rush of the morning was an example of their slowness, he did not want to be present when they went at high speed. (Laughter.) He wanted to pay his tribute to the people in Great Britain who made such tremendous sacrifices in order that the United States could continue to enjoy democracy. It was not only the men in the front line who made that glorious victory possible, but the men and women behind the lines, many of whom would pass away without receiving any honours, but who did their share as much as the man who shouldered the guns. The heart of every true American beat in sympathy with England and its tremendous sacrifices. Although the Americans had 2,200,000 men in France, their total casualties for the entire period of the war were not equal to one month's casualties of Great Britain during one of those memorable drives. That fact was appreciated in America. If their deaths had been, in proportion to the American populace as great as those of the Englishmen, not one of their 2,200,000 who went to France would have got back alive. It had been said that if America was inhabited to the same extent as Great Britain they could support 800,000,000 people. That would enable Englishmen to appreciate what a tremendous market the American had at his door. To a very large extent England was a finished country, and had hundreds of years of history, before one line was written on the first page of America.

Naturally, England depended largely upon her export trade, though he had doubted whether anybody realised the tremendous trade waiting to be done. The iron and steel industry was the foundation and the keystone of the world's civilisation. The war had been one of iron and steel. With regard to American production their steel production last year was 43,000,000 tons, the pig-iron production 38,000,000 tons, the grey foundry iron production over 5,000,000 tons, although last year was a poor one for that trade, because many of the products of the iron foundry were put into the non-essential list for the benefit of munitions. The production approximately of steel castings of all kinds was 1,400,000 tons. The production of malleable iron was in excess of 1,000,000 tons. America produced by the black-heart process while England employed the white-heart.

Mr. Backert continued:—"I came over here to tell you fellows how to do things. Instead of that I will keep very quiet. When it comes to precision work and quality of production we must take our hats off to you. At Sheffield in some of the iron and steel plants I saw some of the most wonderful work I have ever seen in my life. The care you exercise in heat treating your steel and, as I learned to-day, also in heat treating your castings, cannot help but make a wonderful and dependable product. It seems to be a big trait in the Englishman's build, and I think I must attribute the success of your nation to that one fact."

Mr. Backert went on to say that after all he thought there must be a happy medium between high quality and high production. In America they went in for quantity production, while the Englishman was constantly striving for quality, but the American object in increasing output was to reduce the cost of manufacture.

It was a great advantage to Englishmen that their workers were all of the same nationality, and the foremen knew nothing of the experience in America where a foundry manager sometimes had to make signs to his assistants, because the workmen could not understand his language.

Referring to the question of output, Mr. Backert explained that they were able to pay high wages in America because limitation of output was practically unknown, and that contributed to economical production. Wages must be kept up because the cost of living in America had advanced over 100 per cent. during the past three years, and houses were impossible to get, while hotels were crowded. That only meant that when rebuilding commenced both in America and in Europe there would be such a demand as the world had never before experienced.

The speaker concluded with an eloquent tribute to the British soldiers who had fallen in France that the world might enjoy its to-morrow.

Visits at Birmingham.

On returning to Birmingham on Thursday, Mr. Backert spent some time at the Iron Exchange. Friday was spent in a visit to the works of Messrs. Walter Somers & Company, Limited, who have

manufactured large quantities of heavy marine forgings for the war, and whose equipments include a 3,000-ton hydraulic press. A visit was also paid to the famous Watt-room of Heathfield Hall, Handsworth, once occupied by the great inventor, and now the residence of Mr. George Tangye, the veteran surviving partner of Tangyes, Limited. This was a room in the upper storey which Watt fitted with machinery, and after retiring from business spent many of his leisure hours at the bench. Mr. Frank Somers, his host, afterwards motored with Mr. Backert and Professor Turner through the Shakespeare district, visting Stratford-on-Avon and the castles of Warwick and Kenilworth.

After other works' visits on Saturday, Mr. Backert journeyed to Sheffield on Saturday afternoon.

SHEFFIELD RECEPTION.

Mr. A. O. Backert, President of the American Foundrymen's Association, was accorded a most enthusiastic reception on the occasion of his visit to Sheffield on Saturday, May 3. In honour of the visit Mr. T. H. Firth, President of the British Foundrymen's Association, entertained about 120 members of the Association and representatives of the great Sheffield firms to dinner at the Grand Hotel. The gathering was a memorable one in the history of the foundry trade of Great Britain, captains in the industry attending from all parts of England and Scotland.

The loyal toast having been honoured, the Chairman remarked that he did hope that the great minds across the water would be able to settle the difficulties that had arisen, that the Allies would be united, and that we should soon have that glorious peace we were all looking for.

Mr. J. M. Savage, American Consul at Sheffield, said it gave him very much pleasure to propose the toast of "The City and Trade of Sheffield." If he might be allowed to change the wording to "Prosperity to the City and Trade of Sheffield." It so happened that he was assigned to that important manufacturing centre almost immediately war was declared, and therefore during the last five years he had been a witness of the unprecendented prosperity which all classes of the community had enjoyed. During the whole of this period it had been necessary for their energies to be mainly devoted to the production of munitions of war, with the result that not only the British Empire, but the civilised world owed a debt of gratitude to Sheffield industry for the part they had played in bringing about the result which was so satisfactory to them all. Now, however, that the "Dogs of War" were being chained, and he trusted effectually chained, there were many difficult problems that confronted their captains of industry, but he had faith that the men who were able in many cases to revolutionise industries and place things on a war basis would be found equally capable in the tasks that confronted them. Another result that the war had wrought had been to greatly increase the earnings of the working classes of this country, and make it possible for them to enjoy to a greater extent than before the fruits of their industry. He rejoiced that this was so, but at the same time it had placed a responsibility on the wage earners that they were bound to respect, if the commercial prosperity of this country was to be maintained. England had been described as the "Workshop of the World," and they must realise that they would have to meet the competition of other countries, some of which had not heretofore been largely engaged in export trade. If, therefore, they were to get their fair share of this business, and anything like the present scale of wages was to continue, the workers must co-operate with their employers; all harmful restrictions must be removed, and the maximum of production maintained. The prosperity of a nation to a large extent depended upon the prosperity of other nations, just as the prosperity of individuals depended on the prosperity of other individuals, and it was to be hoped that no trade war would follow the recent conflict, but that each nation would find a ready market for those things it was in a position to supply, and that prosperity, as well as peace, might be enjoyed by all.

The Lord Mayor of Sheffield (Alderman W. Irons), in reply, said Sheffield had not yet reached the zenith of its fame. Those great principles that had made Sheffield famous would still be continued in a greater degree, and by the closer co-operation of employer and employed they might yet do greater things, and the name of Sheffield attract added renown. They were now face to face with great industrial problems. England would have to face the markets of the world. Unless there was great co-operation between English masters and men they would have serious difficulties in the future. He hoped the prosperity of Sheffield would be continued more and more, and that those who came after us would thank those of this generation for the great efforts they had made in founding the great prosperity of the city of Sheffield.

Mr. P. B. Brown (Messrs. Hadfield's, Limited), who also replied, said Sheffield was a city they were all exceedingly proud of, and its traditions were such that no one ever need be ashamed of. He believed Sheffield working men, if properly treated, and were not misled by those who were out to mislead them, were the finest workers that we had in this country. What they had to do was to encourage those men to look at things from the point of view of putting their best into industry. Unfortunately at the present time a large number of workers were not looking at it from that point of view, but they must not be too hard in their judgment with regard to the workers in Sheffield, or Great Britain. He did honestly believe that the working people in general had had such a shaking up on account of the war that they were living in a state of exceedingly great uncertainty; they had lost their balance, and it was up to those who had some influence to see that their means of livelihood were retained throughout the present period. If they did this the prosperity of Sheffield was absolutely assured. It was unbelievable to think that the workers would ever go back to the wages they had before the war or to the conditions they were in before the war. None of them wanted to go back to those conditions. They were aiming at something brighter and better than they had ever experienced in the past, and it was just possible that that was the keynote of the unrest that was spreading all over the world.

The Chairman then proposed "The Health and Prosperity of the President of the American Foundrymen's Association," and was sure that they would accept this as the toast of the evening. They were all delighted that Mr. Backert was with them. Mr. Backert was not only a journalist, but knew something practically about what he wrote, and the Papers he had given before his Association on moulding machines and other subjects had been read with very great interest. But they had

not got everything in America. The American Foundrymen's Association was founded in 1896 and had a membership of 1,300. The British Association was founded very much later, and had now a membership of about 1,500.

Mr. A. O. Backert, who was accorded a most enthusiastic reception, said he thanked them for this ovation from the bottom of his heart. This was not an ovation to the American Foundrymen's Association; it was not an expression of appreciation on their part to the man who represented that Association, but it was an expression of friendship, of brotherhood, on their part, to the American people. He would do his utmost to help build a bridge across the Atlantic which for ever would tie together the two great English-speaking nations of the world. They had been waiting for some months for the Peace Treaty to be signed, but regardless of all that this war would not have been in vain if it tied together for evermore the United Kingdom and the United States. He came here to convey to them the feeling of friendship of the American Foundrymen's Association—friendship of the members of that Association to the members of the British Foundrymen's Association, and not only to the members of the British Foundrymen's Association, but to all members of manufactories in England. He extended to them an invitation to the International Exhibition, which was an Inter-Allied Exhibition, to be held in Philadelphia on September 29.

Continuing, Mr. Backert said he knew Sheffield was a great city, and he wondered if they realised that no district in the entire world was so fortunately situated in respect of its raw material. They had their Pittsburg, but they brought ore to Pittsburg for a thousand miles. There was nothing in their country that approached the Sheffield district. The labour situations in America to-day were somewhat analogous to those in England. They needed men to go into the workshops and so-called unskilled labour was placed on single-purpose machines. In America the bonus system was in vogue, and high wages prevailed everywhere. As they got on to that basis those men considered themselves skilled men. The man who drove a few rivets was a boilermaker, the man who helped in a blacksmith's shop was a blacksmith, and they had no more unskilled labour in the United States of America! They enlisted the services of a good many women, and many of those women were going to be retained. As a result of this war woman deserved her place in the sun. There was not, however, union labour domination in the United States of America; but he did not want them to think that American labour, because it was not so highly organised as ours, was not receiving its just due. He had yet to see the manufacturer who refused to pay all that was due to the men on returns and output on which he was paid. In the foundry industry they had 125,000 men engaged, and not more than 25 per cent. were in unions, and those who received the least money were members of the trades unions. Why? Those unions restricted production. The others worked on a piecework basis, and each man could make as much money as he wanted.

The manufacturers of the world were all remiss in that they hesitated to send somebody out to talk to the men and present the employers' side of the case. Within the last three months there had been organised in America a Manufacturers Speakers' Bureau for the purpose of talking to working men in order to speed up and facilitate production. It selected the ablest speakers out of the number, and they from day to day at the noon hour told the manufacturers and workers something.

We were talking about the League of Nations; but there would never be a sound League of Nations unless it was founded upon a sound economic basis. The best news he had heard was the other day when he learned that the steel manufacturers of the United States and this country had been discussing seriously the question of forming an alliance for the purpose of the export trade of the world. France undoubtedly would be taken in. If that were promulgated it would be one of the first real steps towards a real League of Nations.

He wanted to refer to the feeling in the United States towards this country. For the first few months of the war they knew very little of what the United Kingdom was doing. They read about the tremendous sacrifices they were making, and their true American heart beat in sympathy with them. To-day every American knew the wonderful part which Great Britain took in this war. They knew that during some of the big drives their casualties for one month were as big as theirs in America during the entire war. They also knew that we helped to make it possible to bring their army over here—they knew that 50 per cent. were brought by British boats. They also knew another thing, that the British Army might have been pressed, but it had never been "busted." They knew that if the Allies had been driven into the sea there was the grand old British Fleet. That was why the two great English-speaking nations of this world should be united and two hearts should beat as one. He wanted to express his very deep and heartfelt appreciation of the many courtesies that had been extended to him since he had been in England. He wanted to thank the manufacturers who had done his country and his people that very delicate courtesy, and raised the Stars and Stripes when they knew he was to pay that visit. He hoped and prayed that some day they might have the opportunity to reciprocate it on their side of the water. (Cheers.)

Mr. Wm. Clark (Vickers, Limited) proposed the toast of "The Army, Navy and Air Forces," and referred to the spirit which had actuated all units of the British Forces during the past five years. Now they should endeavour to carry into the ranks of industry that camaraderie and good feeling which had existed between the rank and file in the trenches, and they would see a change for the better in all their industrial work. It was up to those who were in a position to do so to assist those who had done so much for them. They should engage in their sport, they could help them out of their difficulties, and do what their officers had done at the front. If such were done then the employers would reap some reward.

Commander Mark Rundle, D.S.O., R.N., responded to the toast.

Dr. W. H. Hatfield, D.Met. (of the Firth-Brown Laboratories), in proposing the toast of "The University of Sheffield," said the application of science to industry was the direction in which their thoughts must go if they were to bring about that happy state of things of which Mr. Backert had been speaking. In Sheffield they had a University of indigenous growth. They looked forward to the city of Sheffield increasing in its influence and prosperity, and that could only be attained by their University progressing proportionately. There was not another University in the world where there was a Faculty of Metallurgy, and he

thought he was right in saying it was proving of very great service to the iron and steel industry. Sheffield could rightly claim to be the centre of the scientific study of metallurgy since Dr. Sorby laid its foundations.

Dr. Ripper (Vice-Chancellor of the University), in responding to the toast, said he felt that nothing they could do in this country was too good to repay the hospitality which had been extended by America to British visitors. He was glad to say that at the Sheffield University they had sixteen army officers from the American Army receiving instruction. They were sent by the American Government as a first instalment. They did not intend in the future that American students should only have German universities to go to. The British Universities for many months past had been meeting in London, and had drawn up a complete course of study, at the end of which the degree of Ph.D. would be conferred upon the successful candidates. That degree in the past could only be attained at the German Universities. They should remember that the great future which lay before them was full of serious problems which would test their quality, character, stability, and power to meet them. There was only one way in which they could do that, and that was by preparing themselves, and the University felt that it was an honourable task to help to prepare the younger men, who in time would take their places. Without a sympathetic spirit of appreciation, men like themselves, engaged in scientific industry, could not hope to do what they desired to do. It was a very great encouragement and help to find working with the University men who had passed through their ranks like the President (Mr. Firth) and Dr. Hatfield, who were always ready to support and help to continue the work which they all so much desired to see carried out.

The concluding toast was "The Visitors," proposed by Mr. John Watson, and was responded to by Mr. T. W. Willis, President of the Sheffield Society of Engineers and Metallurgists.

During his stay in Sheffield Mr. Backert was the guest of Mr. Thomas H. Firth at his residence in the outskirts of the city, and on Sunday he enjoyed a motor tour through the Derbyshire dales and visited the beauiful surroundings outside the borders of the city of Sheffield, inspecting the gigantic reservoir from which the water supply of the city is obtained. Among other places, Chatsworth House, the palatial residence of the Duke of Devonshire, was visited, the tour comprising about 150 miles.

On Monday morning Mr. Backert called on his way to Birmingham and visited the works of the Leys Malleable Castings Company, Derby, and the works of the Rolls Royce Motor Company, where the proprietors had many details of interest to show him.

FUNCTIONS AT BIRMINGHAM.

The concluding welcoming function of the Midlands was arranged by the joint Societies of the Birmingham Branch of the B.F.A., the Birmingham Metallurgical Society, the Birmingham Local Section of the Institute of Metals, and the Staffordshire Iron and Steel Institute. Mr. Backert was entertained at the Queen's Hotel on Monday evening, May 5, the dinner being presided over by Professor Turner. Amongst those present were the Deputy Lord Mayor (Sir William H. Bowater), Sir Gerard A. Muntz, Bart. (Muntz, Limited), and the American Consul (Mr. W. T. Gracey).

The toast of "The King" was proposed by Mr. Backert, and Professor Turner next asked the company to drink to the honour of the President of the United States. At no time in the history of the country would such a toast be received with greater heartiness. The two countries were closely allied; although America had its own literature and institutions, yet there was a great identity and spirit of aspiration.

The toast was received with great heartiness.

Sir William Bowater (Deputy Lord Mayor), proposing the toast of "Our Guest," said he believed such visits would do very much in promoting the true union of the two great English-speaking nations. The close co-operation of the American army and navy had improved the mutual regard of both nations. While the Americans did not at first realise the sinister designs of Germany against the world's freedom, when they did come in they did their work thoroughly. While their enemies were trying to play off the nations against each other, they could not diminish the love and respect with which this nation regarded the Americans.

Mr. A. O. Backert, who was received with great enthusiasm, said he meant to do his little bit towards cementing that good feeling between nations in whose hands lay the destiny of the world. He had brought with him a message of friendship from the American Foundrymen's Association, and he wished particularly to extend to them a hearty invitation to their great Exposition in Philadelphia at the end of September, when Americans would endeavour to return the many courtesies shown to himself. The Exposition was commenced about twelve years, and had now reached enormous proportions. It occupied 90,000 feet of floor space, and visitors would find every modern piece of equipment or machinery employed in connection with iron founding. Before he came to Birmingham he had heard the city described as the workshop of the world, and probably it had more diversified industries than any other city of its size, and because of its great reputation they had applied its name to the well-known city of Birmingham, Alabama.

The speaker emphasised the necessity of restoring the financial balance between the two nations, and that could only be done by large exports of British goods. Unless the British did that, the only alternative was for the Americans to come over here and build plants, employing British workmen, and in that way restore the sovereign to its normal value. One thing which struck the visitor was that Englishmen kept their sorrows to themselves. He now understood that it was typical of the British race to be reserved. But when its great spirit was stirred, their enemies, like the Kaiser, knew the result. He assured them how deeply Americans sympathised with the bereaved in Great Britain.

The toast of "The Kindred Metallurgical Associations" was proposed by Mr. W. T. Gracey, the American Consul, and was responded to by Sir Gerard Muntz.

General Meeting at the Birmingham Branch.

Professor Turner again presided at the joint meeting of the Associations held in the Medical

Theatre of the Birmingham University, where there was a crowded audience of members, many of whom had come in from the surrounding towns. The Chairman welcomed Mr. Backert on behalf of the four metallurical societies of the district. Mr. Backert would be interested to know that the Staffordshire Iron and Steel Institute was the oldest institution of its kind in the country, while the Birmingham Metallurgical Society had a membership of 500. The Foundrymen's Branch and the Local Section of the Institute of Metals were both thriving Associations, and they had all rendered great help to the district. The demand for trained scientific men, which had already outgrown the supply, would be still greater in future. He could assure Mr. Backert not only of their personal regard, but of their great interest in metallurgical progress throughout the world.

Mr. Backert, who was received very heartily, said he was proud to be received by that combination of learned bodies, especially under the presidency of Professor Turner, one of the most renowned metallurgists in the world. Science was really the only international language, and in that language Professor Turner had talked to the people of the world. He was very glad to assure him of the great regard felt for him by the American foundrymen. Referring to the foundry business of the United States, they were blessed with unusual material resources, comprising two very large iron-ore basins, one at the northern section of the States, and the other almost in the same position in the south. The ore from the northern section fed the blast furnaces in the central west, in the Pittsburgh district, and very largely also in the east. With other resources in Virginia and elsewhere the foundryman had an unusually wide opportunity for the selection of his pig-irons. He could obtain high-silicon or comparatively low-phosphorus iron in the north, or conversely could obtain high-phosphorus iron in the south. It was very rare for a blast furnace to have a burden containing less than 50 per cent. of iron, and it could readily be understood what that meant in increasing output and reducing fuel consumption. On the other hand, they had an abundance of fuel, and while the price of coke soared to 16 dollars, it had since been reduced to about three dollars a ton for furnace use. The price of American pig-iron was from 10 to 15 dollars, or £2 to £3 less than British iron. Then there was not the same difficulty in obtaining the fuel supply as in England. Since the war commenced, America had tremendously increased its steel production. At the same time, the pig-iron production had not kept pace with the steel producing capacity, with the result that at the time of the Armistice scrap was selling at a price as high, and in some cases slightly higher, than pig-iron, simply because pig-iron was not available. There was now an accumulation of shell steel in America of about 750,000 tons, which would have to be used for scrap.

The American steel-producing capacity was about 50,000,000 tons, but they could not turn out that quantity through insufficient supply of pig-iron. The position was very analogous to that of Great Britain. Numerous plants had been laid down during the stress of war, and their owners, instead of scrapping them, meant to try to make a little more money. The British steel output last year was 10,000,000 tons, and the pig-iron production was about a million tons less. That meant that the two countries were producing the bulk of the world's iron and steel. The Germans last year produced 13,000,000 tons of steel and 9,000,000 tons of pig-iron. Probably the balance of 4,000,000 tons represented machinery of all kinds and other materials stolen from Belgium to feed the steel furnaces, thus making up for the German shortage of materials. The constantly increasing "spread" between steel output and pig-iron production showed that the Germans were unable to get a sufficient supply of iron, though, no doubt, they ransacked Belgium and Northern France for their supplies. That was why Belgium had only four or five of its sixty furnaces able to work. The Belgians' plant had been so wrecked that he doubted very much whether Belgium would be able to produce iron in less than a year, and probably then only to 50 per cent. of its capacity. France was in a slightly better position, and would benefit by the acquisition of the Ruhr mines, as well as those of Alsace and Lorraine. Italy was not a large producer, and, as in the past, would probably continue to be a buyer of iron and steel for a term of years. It was clear that the iron and steel trade of the world to a very large extent would have to be taken care of by France, the United Kingdom and the United States. Germany must have a lessened pig-iron and steel production through the loss of Alsace-Lorraine, and for some time would not be in a position to compete in the world's markets even if permitted to do so. But Germany, before the war, produced 19,000,000 tons of steel and 18,000,000 tons of pig-iron, which showed its tremendous capacity, particularly in the manufacture of steel castings. In 1913 German steel castings were being quoted in the interior of the United States underselling American steel castings at a time when they were probably lower in price than they had been for many years. The German competition was largely due to the system of bounties.

The speaker proceeded to refer especially to the foundry industry. It was commonly supposed here that the American output per man was twice that of Great Britain. He could not say whether that was correct, but at a large plant he had visited that day the production per man was just half of a similar plant in the United States. He could not say whether that represented a British average. The American foundryman had made large use of labour-saving equipment. He did not believe any manufacturer introduced such equipment until he was obliged, although occasionally a manufacturer, very enterprising, would have the very latest thing in his plant; but generally they found that skilled labour shortage and increasing wages were the compelling factors.

Mr. H. L. Reason, the President of the Birmingham Foundrymen, proposed, on behalf of the four kindred Associations, a hearty vote of thanks to Mr. Backert for the honour conferred upon them by his visit and for the admirable address he had delivered. He could assure Mr. Backert that, on behalf of all the Societies, he extended the right hand of friendship. Mr. Backert had conveyed to them the best wishes of the American Foundrymen's Association. He was quite sure that Mr. Backert's visit would strengthen the link of affection between the two countries.

Mr. George Carrington, President of the Staffordshire Iron and Steel Institute, seconded, and Mr. F. C. A. H. Lantsberry, President of the Local Section of the Institute of Metals, supported the vote.

British Foundrymen's Association.

NEW COVENTRY BRANCH.

A meeting for the formation at Coventry of a Branch of the British Foundrymen's Association was held at Coventry, on Monday, April 7, when there was a large attendance. Mr. A. P. Smith was elected to preside over the preliminary proceedings, on the proposition of Mr. A. Harley, seconded by Mr. Hurren.

Letters of apology were received from Mr. Thomas A. Firth (President of the Association), Capt. Alexander Hayes (General Secretary), Mr. Chas. Grindley (late Secretary of the Birmingham Branch), Mr. H. B. Jackson (Coventry), Mr. F. E. Shearman (Secretary of the Birmingham Branch), Mr. H. Winterton, and Mr. Roe (Birmingham), all of whom conveyed their hearty wishes for the success of the Branch.

The Chairman explained that the meeting had been called to form a Coventry Branch of the British Foundrymen's Association. The parent body was established in 1904, beginning in quite a small way with a membership of only eight. Several of the original promoters were now present, including Messrs. Cook, E. H. Broughall, and R. Buchanan. The movement went forward very successfully, so that within twelve months the membership reached about 100. Since that time Branches had been established in Birmingham, East Midlands, Lancashire, London, Newcastle, Peterborough, Scotland, and Sheffield. Quite a number of the Coventry foundrymen were members of the Birmingham Branch, but a number of Coventry foundrymen had appealed to the General Council for permission to start a new Branch, and that permission had now been received. The speaker proceeded to give particulars with regard to the objects of the Association, classes of membership, etc., and pointed out that the total membership of the Association now exceeded 1,250. He thought it was not too much to hope that they would add another 200 or 300 in Coventry.

Mr. Andrew Harley, of the Daimler Motor Works, in expressing a special welcome to the members of the Birmingham Branch, said it was quite true that to some extent they were breaking away from Birmingham, and it showed a very generous spirit on the part of the Birmingham members to have come over in such numbers to help in the starting of the new Branch. They welcomed especially two of the original promoters of the Association, Mr. Buchanan and Mr. Cook, as well as Mr. Reason, who was the President-elect of the Birmingham Branch. He then gave a *résumé* of the steps already taken in the direction of inaugurating the Coventry Branch, in which support was received from the following gentlemen, who were present at the meeting:—Messrs. J. R. Handforth and E. H. Broughall (Messrs. Alfred Herbert, Limited), D. Cartwright (Reliance Foundry Company), A. Harley (Daimler Company), Jas. Gaunt (Sterling Metals, Limited), E. M. Boote (The Martino Testing Company, Limited), Williams (British Chuck and Piston Ring Company, Limited), Roberts (Duggans, Limited), Archer (Coventry Engineering and Pattern-making Company), A. P. Smith (Britannia Foundry Company), E. Cox (Rover Company, Limited), Perks (Phœnix Foundry Company), Rose (Phœnix Foundry Company), Sherland (Messrs. Alfred Herbert, Limited). Support was also promised from Mr. E. Player (Sterling Metals, Limited), and Mr. Hurren (Rover Company), Mr. A. H. Niblett (Humber, Limited), Mr. George Wilson, Mr. Watson (Matterson, Huxley & Watson, Limited), Mr. Carey Hill (Rowland Hill & Sons, Limited), and Mr. Birkett (Motor Foundry Company).

Consent of the General Council of the Association having in due course been obtained, it now only remained for the Coventry foundrymen to confirm the decision to form a Branch.

Mr. E. H. Broughall proposed a resolution endorsing the action of the Provisional Committee, and expressing the approval of the meeting to the proposal to form a Branch. There was, he said, really nothing at the present time to educate foundrymen, who required technical education more than any member of the engineering trade. The foundry worker was bound to have scientific knowledge, and was much more in need of it than the ordinary fitter or turner. There was about to be built in Coventry, though he did not know whether they would all live to see it, a new Technical College, and several of them had made up their minds that there was to be a department at the disposal of foundrymen and foundry apprentices. He wished to assure the workmen that this was not an employers' dodge. There were occasions when discussing certain subjects they had to sit at different sides of the table, but in this Association they would both be on the same side of the table, and what they did would be to their mutual advantage.

Mr. A. H. Niblett, in seconding the resolution, said that they had very largely in the past ignored the scientific side of their work, and if they were to compete with other nations they must come down to fundamental facts. It was most essential that they should take the younger members of the trade and educate them in works metallurgy.

Mr. F. J. Cook (Past-President of the Association), supporting, reviewed briefly the growth of the organisation. At present the General Council of the Association comprised members from all over England, Wales, and Scotland. He quite agreed with Mr. Broughall that the great object was to educate the rank and file and elevate them in their sphere of life, as well as to improve the work of iron founding generally, and maintain their position at the front of the industry throughout the world. He believed that no society that had ever been formed could show equal results, and before it was formed it was practically impossible to meet a foundryman who knew the basis of cast iron. That position had been entirely changed, and it was now difficult to find a foreman who did not know a great deal about the constituents of iron, as well as of their action.

Mr. R. Buchanan said that the scientific study of their most interesting trade merely meant that they got an understanding of the laws which applied in their daily work. In that direction the B.F.A. had wrought a revolution in regard to the respect with which that branch of engineering was regarded. It used to be a general idea that founding was very simple work, indeed, to which the poorest class of intellect could be applied; but those who had gone into the subject closely realised that there was no more intricate or intellectual or interesting work to which a man could apply himself than founding in its various branches. The task of wrestling with difficulties and exchanging views had broken down the old secrecy, and taken away the conceit of some founders who thought

they knew all there was to know. He (the speaker) was certain that the Coventry Branch would be a credit to the Association, as well as a source of strength. While he regretted the loss of Coventry men from the Birmingham Branch, he was glad to acknowledge their past services, which had been of the greatest value, and the Association as a whole would thereby be strengthened. He wished them all a most prosperous career.

The resolution was carried with acclamation.

The meeting proceeded to the election of officers.

THE CHAIRMAN proposed the election of Mr. Andrew Harley as first President. Mr. Harley was a metallurgical chemist by profession and a foundry manager by trade. He was a man of great foundry experience, and a keen supporter of the Association. They might be interested to know that, but for the formation of that Branch, Mr. Harley would have occupied the chair of the Birmingham Branch during the next year. He had given up that position to help Coventry.

MR. CAREY HILL, in seconding, said that it was on Mr. Harley's initiative that the preliminary meeting had been called. It appeared to him (the speaker) that the Branch was being formed at a most opportune time. A great deal had been said about the revival of scientific work in engineering and in other trades, and many founders had been very glad to take advantage of the scientific knowledge which had been so freely interchanged during the war. He gladly acknowledged the help which had been given them by the Government and the Ministry of Munitions, and the fullest use had been made of the special organisation which had been established. He hoped that as the various firms who, during the war, got together co-operating and collaborating and placing their scientific experts, so to speak, at the universal disposal, they would continue that policy. A good deal of valuable information had been distributed and would still be of service to them during the period of transition, when they were changing swords into ploughshares, their bayonets into trowels, and their mess-tins into water-pots. (Hear, hear.)

MR. H. L. REASON supported the proposition, which was carried unanimously.

Mr. E. H. Broughall was elected Senior Vice-President, and in proposing him MR. D. CARTWRIGHT reminded the meeting that though the Association dealt principally with iron, it paid a great deal of attention to aluminium, gun-metal, brass, copper and other non-ferrous metals.

Mr. F. H. Hurren was elected Junior Vice-President on the proposition of MR. A. H. NIBLETT, who pointed out that Mr. Hurren had been a very active member of the Birmingham Branch.

MR. E. H. BROUGHALL, proposing Mr. J. Gaunt for the Secretaryship, expressed his great regret that Mr. Gaunt was at present suffering from pneumonia. He was sure they would desire to send their sympathy to him. He was specially qualified for secretarial work, as he was a member of the General Council and a former Secretary of the London Branch.

MR. A. HARLEY, in seconding, said that the Coventry Branch might have been formed a considerable time ago but for the difficulty in getting the right man to become Secretary. The resolution was carried.

The following were elected members of the Council :—Messrs. A. P. Smith (Britannia Foundry Company, Limited), E. Carey Hill (Rowland Hill & Sons, Limited), W. A. Oubridge (British Chuck and Piston Ring Company, Limited), G. Roberts (Coventry Malleable, Limited), E. Whitworth (Daimler Company, Limited), F. H. Rogers (Rover Company, Limited), A. Stynes (Alfred Herbert, Limited), L. Haxby (Humber, Limited), and S. Reordon (Motor Foundry).

MR. ANDREW HARLEY (installed in the chair as President) pointed out that there was a rule that a Branch could not be started with less than 30 members, but he was glad to say that as a beginning there would be at least 150.

The meeting was followed by a smoking concert.

BIRMINGHAM BRANCH.

The annual meeting of the Birmingham Branch was held on April 12, Mr. H. L. Reason presiding.

Mr. F. Holbery proposed the election of Mr. H. L. Reason as President of the Branch for the ensuing year. The nomination, having been seconded by Mr. H. Winterton and supported by Mr. H. Pemberton, was unanimously approved.

MR. REASON, thanking the members for his election, reminded them that it was exactly eight years ago since he first held the position. He pointed out that he had accepted the nomination owing to the circumstance that the senior Vice-President, Mr. Harley, had taken the responsibility of forming a Coventry Branch, and had accepted the position of its President. As an experiment to improve the attendance of the meetings of the Birmingham Branch it had been suggested that mid-week meetings should be held during the next session. In the new programme this would be arranged.

On the motion of Mr. Reason, seconded by Mr. C. R. Roe, Mr. F. Holbery and Mr. Wright (Wolverhampton) were unanimously elected Vice-Presidents of the Branch.

Mr. J. J. Howell and Mr. F. Holbery were appointed the representatives of the Branch on the General Council.

The following were elected to form, with the officers, the Branch Council for the ensuing year :—Captain Bayliss, and Messrs. W. J. Flavell, C. Grindlay, F. C. A. H. Lantsberry, C. B. Pugh, C. R. Roe, T. Vickers, H. Winterton and H. Brain. Mr. Vickers and Mr. Roe were appointed auditors.

New Branch Secretary.

Mr. H. Field, 12, Bayswater Road, Handsworth, was elected Branch-Secretary, in succession to Mr. F. E. Shearman, who had found it necesary to relinquish the work.

The hon. secretary (Mr. F. E. Shearman) in his annual report stated that several joint meetings had been held with the Birmingham Metallurgical Society and the Staffordshire Iron & Steel Institute, and one with the Coventry Engineering Society, all of which had been well attended and thoroughly appreciated. A visit has been made during the session to the works of Messrs. Siddeley-Deasey Company, Coventry. The Branch membership at present was 183, 41 having joined during the session.

THE BRANCH-PRESIDENT said that their hearty thanks were due to Mr. Shearman for the work he had done for the Branch during the past year. He proposed that they give a hearty vote of thanks to Mr. Shearman, and this having been carried by acclamation, Mr. Shearman acknowledged it, and explained that now things had become normal again he had not so much time on his hands as when he took over the office. Otherwise he would have been willing to continue the work. He believed, however, that Mr. Field would prove an able successor.

Electric Vacuum Muffle Furnaces.

Open-type muffle furnaces, fired with gas, coal or coke, are doing great service, but they have certain inherent defects, such as the presence of oxygen in the muffle, occasional intrusion of the flame into the muffle, want of uniformity of temperature on all parts of the muffle-floor, difficulty of obtaining and maintaining a definite temperature, and also the difficulty of indicating by a pyrometer what the exact temperature in the muffle is. The difficulty of the oxidation of steel under heat treatment in a muffle has been to an extent solved by the introduction of inert gas into the muffle; but it is not a complete solution in cases where large quantities have to be dealt with. To use the muffle efficiently, and that no time be lost, a constant procession of charges in and out of the furnace is required. A procession of large quantities, however, cannot be dealt with properly in fixed locks filled with inert gas attached to the muffle, as a hold-up must occur. To prevent this, portable locks would have to be employed. These, however, charged with the various inert gases in use, would not be safe, owing to the danger of explosion.

FIG. 1.

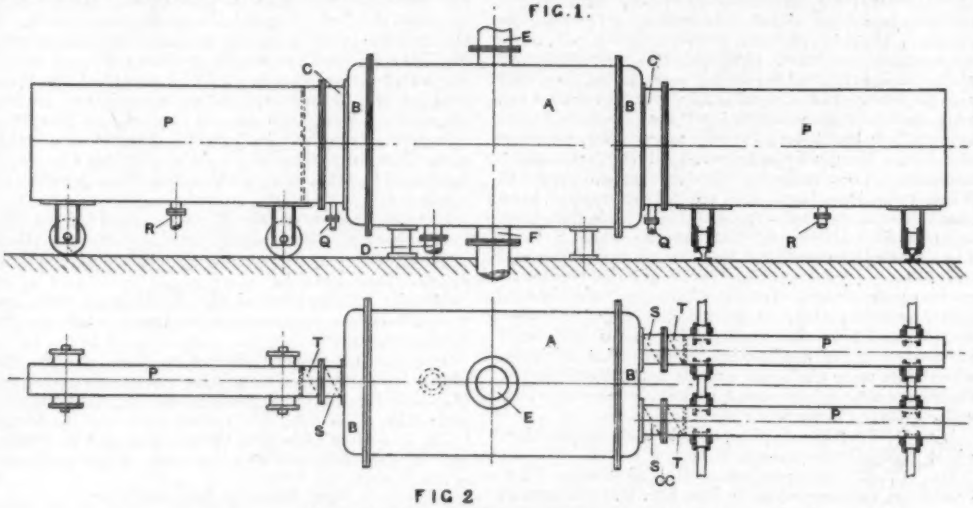


FIG 2

ELECTRIC VACUUM MUFFLE FURNACE.

Moreover, with portable locks, alternately filled with inert gas, and with air after the gas had been evacuated, the contents of the locks would be uncertain, and the introduction of highly heated metal into them attended with danger.

Bearing all this in mind, the suggestion at once occurs to exclude both air and gas, and to use a vacuum with internal electric heating. The vacuum need not necessarily be good to secure favourable results; but if every trace of oxidation is to be avoided all oxygen in the muffle must be either eliminated or rendered harmless. Small quantities of oxygen appear to produce brilliant and beautiful colours on steel, and sometimes a complete spectrum. Peacock blue, pink and red seem to occur most frequently. These colours are not due to variations in temperature, as the colours occur with uniform temperatures of over 800 deg. C. The amount of oxygen to produce any given colour has not yet been determined.

It is not possible, with a muffle in workshop practice, to withdraw entirely all oxygen from its interior, but a 27-in. vacuum can be obtained, which is sufficient for most practical purposes, precluding the formation of scale but not all trace of colour. To free the muffle from oxygen entirely, an old laboratory method can be followed; the remaining air can be circulated through a small electrically heated furnace charged with steel or iron turnings with which the oxygen will combine. The turnings are to be renewed when oxidised. It may be suggested that the vacuum might be dispensed with, and the muffle air with its full complement of oxygen might be circulated through a small auxiliary furnace, and its oxygen absorbed, practically only nitrogen remaining in the muffle. This, however, would probably not prove satisfactory, as the nitrogen would be liable to be occluded in the steel or iron and prove harmful.

Muffle furnaces fired by gas, coke, or coal, have the elements of their own destruction in their principle and design, and are a constant source of expense for repairs and renewals. This has led many to investigate and develop the use of internal electric heating for muffles, and the war has added impetus to this. Great progress has been made in this country, and greater in the United States, where many such plants are now at work on a large scale. It is confidently predicted that the price of electric current will eventually be reduced to ½d. per unit. This will enable the electric muffle to outstrip its competitors. It has already advantage which enable it to compete, such as ease of manipulation, uniformity and reliability of temperature, ease of adjustment to a given temperature, and cleanliness.

The prevalent idea, probably born of the vacuum flask, is that heat will not traverse a vacuum. The vacuum flask, however, deals with a low temperature of, say, 100 deg. C., and then requires to be reinforced by two polished mirror surfaces to make it effective. At the higher temperatures dealt with in a muffle, the heat is transmitted principally by radiation, and little by convection; indeed, owing to the rarity of the air due to its expansion at high temperatures, convection even in open muffles must play a small part.

The best results may be expected from the vacuum electric furnace, as it not only prevents oxidation of the metals treated, but obviates also the destruction by oxidation of its own internal parts, such as heaters, cradles, and fittings, which will inevitably take place in all muffles when oxygen is admitted. Large vacuum chamber plants, complete with doors, locks, valves, and stuffing boxes, are already used extensively for various industrial purposes, so that the difficulties met with in dealing with a vacuum are known, and have been dealt with effectually.

An advantage of the vacuum electric muffle furnace

is that as it prevents the formation of scale it renders acid dipping unnecessary, and thus effects great savings in labour, materials, time, and floor space. In the case of the cold-drawing of tubes and of bars, the gain is very apparent, as these have to be passed many times through the dies, and before each pass require annealing and dipping.

Having thus pointed out the advantages of electric vacuum muffle furnaces in general, we may now proceed to describe the furnace invented and recently patented (No. 120,944) by Mr. Walter F. Jones, of 51, Poplar Avenue, Edgbaston, Birmingham, for the heat-treatment or annealing of steel or other metals in vacuo by electric heaters enclosed in the furnace.

Fig. 1 is a side elevation, and Fig. 2 a plan of a rectangular muffle, A, with three portable lock chambers, P, P, P; an air-tight door S, is provided in each door-box C, and one also, T, in each lock-chamber. D, Q, and R are air-pipe connections to the vacuum pump. At one end of the muffle two lock chambers, P, are shown on rails, and at the other end a chamber is shown running on the floor as an alternative.

The method of operation in the case of a rectangular furnace is as follows:—The muffle doors S are closed, and the vacuum pump set to work to maintain a vacuum in the muffle. When absolute absence of all oxygen is essential any air remaining in the muffle is then circulated continuously through a small hermetically sealed furnace by a fan, the oxygen being absorbed by steel or other metal turnings or other material with which it is charged. The electric current is then switched on, and the heaters in the muffle are brought up to the required temperature. A suitable condition being established in the muffle, a portable lock chamber P, with its cradle of tubes or other articles to be heated, is secured to it at CC either by swing bolts or other devices, and, door T being opened, the lock chamber P and door box C are exhausted through the valve on pipe Q. It is then possible to open door S, and the cradle can be transferred from the lock to the muffle by endless ropes. The door S is then closed, and if required the lock P may be removed, after air has been let into it; or the lock may remain to receive the cradle after the process of annealing or heat treatment. The cradle having remained in the muffle for the time required by the process, is withdrawn into a lock which has been exhausted, and the lock is removed after the door T has been shut. The lock with its cradle of tubes is then wheeled aside to cool, the vacuum being maintained by the portable pipe connection R. When the contents of the cradle in the lock have cooled below the temperature at which oxidation is possible, the air is let into the lock, the door T is opened, and the cradle drawn out.

In another design a tubular muffle is used, mounted on trunnions, to enable it to be rotated, and the tube under treatment can be tipped for quenching into a water or oil tank without loss of time and heat.

The inventor states that he has experimented with the muffle up to 1,100 deg. C.

Silica Refractories.

A recent "Technologic Paper" of the U.S. Bureau of Standards deals with the factors affecting the quality of silica refractories, their manufacture, and the method of testing the raw materials as well as the finished ware. By far the larger part of the silica brick manufactured in all countries are made from quartzites of comparatively early geologic age. Suitable quartzites range from hard, highly metamorphosed varieties having tightly interlocking grains to medium soft rock, which is slightly porous. Loose-grained quartzites and sandstones are, however, of little value. Quartzites that are now being used range from very young rocks back to the oldest sedimentaries. As possible improvements (for certain materials) in the method of grinding and moulding silica bricks the use of sized material is suggested mixed in a machine similar to a concrete mixer to avoid further crushing of the grains as much as possible, and machine moulding with a pressure of about 1,500 lbs. per sq. in.

Owing to the present large demand for silica refractories, the tendency is to burn them as rapidly as possible to a temperature about equivalent to that required to cause Orton's pyrometric Cone 18 to bend over. The experiments conducted in the Bureau's laboratory show that at temperatures from 1,250 to 1,350 deg. C. there is a slight fluxing or drawing together of the particles of a raw brick, and that at these temperatures transformation of quartz to the forms of lower specific gravity takes place at a moderate rate. Thus, these temperatures insure minimum porosity and a medium rate of transformation. At higher temperatures, however, the transformation takes place rapidly, causing the porosity of the brick to increase unduly. The possible improvement in method of burning silica bricks given below is based on the data gathered during the experiments, and is as follows. The temperature is gradually raised to 1,250 deg. C. in the usual manner and is then kept at from 1,250 to 1,350 deg. for several days, at the end of which time it is gradually raised until Cones 18 to 20 bend over.

The heating tests with raw commercial bricks brought out the fact that mixes made from the principal commercial quartzites all transform at about the same rate at temperatures from 1,200 to 1,500 deg. C. and that the final specific gravities of all are very close together and in the neighbourhood of 2.30. However, bricks made in the usual way from pure chert rock transform much more rapidly than do bricks made from quartzite, and the resulting brick is high in tridymite (specific gravity 2.27). Such chert brick when well burned, may prove of value in work which is subject to rapid changes of temperature. The heating tests also showed that the transformation taking place in commercially burned bricks on being reheated are essentially the same as those taking place in raw mixes. Thus, when underburned bricks are heated for extended periods to 1,200 deg. or higher, as in by-product coke ovens or gas benches, any quartz present will transform and cause an expansion of the exterior volume of the piece except as this expansion may be in part counteracted by drawing together of the particles of the brick due to soaking at high temperatures.

The specific gravities and porosities of most of the leading varieties of commercial silica brick have been determined, and all varieties thus far tested have specific gravities between 2.65 (the specific gravity of quartz) and 2.27 (the specific gravity of tridymite). Bricks made from chert rock, when well burned, have a specific gravity very close to the lower limit. The average specific gravity of all varieties so far tested is 2.384, and the average porosity of the same is 26.34 per cent. The limits of porosity found are 22.6 and 31.5 per cent.

The results of the Bureau's own work in this connection and more recently that of other active operators in the testing of silica refractories, indicate that the relative position of the specific gravity of a silica brick between 2.65 and 2.27 is a definite indicator of the degree to which the brick has been burned, and in conjunction with the porosity, indicates approximately what the subsequent expansion of the brick will be in use. The porosity and specific gravity changes were obtained by computation from the dry weight of the piece, its weight when saturated with water and its weight when suspended in water. Thus, by a simple procedure the manufacturer can keep an accurate check on the nature of the silica bricks he is turning out, and in the same way the consumer can determine what to expect from them in actual use.

Trade Talk.

In future the business of the War Risks Insurance Office will be carried on at 53, Cornhill, E.C.3.

The North British Locomotive Company, Limited, are making considerable extensions to their works at Glasgow.

A fire occurred recently at the premises of the King's Norton Metal Company, doing considerable damage.

The Roslant Engineering Company, Limited, is being wound up voluntarily, with Mr. C. H. Lawson as liquidator.

The United Steel Companies, Limited, are damping down blast furnaces at Solway and Maryport, and two at Harrington.

A winding-up order has been made against the Beck Engineering Company, Limited, Eden Works, High Road, Hayes End.

Slight damage has been caused by fire at the works of Messrs. C. E. Richardson & Company, engineers, of Aizlewood Road, Sheffield.

The Gellings Iron Foundry Company, Limited, is being wound up voluntarily, with Mr. J. M. Gibson, Sartfell Road, Douglas, as liquidator.

Messrs. G. F. Hazlewood, C. Dent and G. W. Hazlewood, engineers, etc., Birmingham, trading as Hazlewood & Dent, have dissolved partnership.

Messrs. T. K. Watson and G Griffiths, engineers, James Street, Newport, trading under the style of Watson & Griffiths, have dissolved partnership.

The blast furnaces of the Ebbw Vale Steel, Iron and Coal Company, Limited, have been damped down. The steel works are also closing until further notice.

The North-Eastern Steel Works, Middlesbrough, were closed last month for an extensive scheme of reconstruction, and will probably not re-open this year.

Messrs. S. Turton and W. Turton, engineers, 52-55, High Park Street, Nechells, Birmingham, trading as S. Turton & Company, have dissolved partnership.

The directors of Robert Stephenson & Company (1914), Limited, propose to remove "(1914)" from the title of the company, which will then become Robert Stephenson & Company, Limited.

Messrs. I. O. Freiwald, C. Ricard and W. E. Earle, carrying on business as Ricard & Freiwald, 120, Fenchurch Street, London, E.C., have dissolved partnership.

A conference of the shipbuilding and engineering trades at Cardiff recently considered a proposal for the acquisition of the Chepstow national shipyard, but declined it.

An interesting lecture on "Stability in Structures and Designs" was given before the Leeds Association of Engineers on April 24 by Mr. J. Gilchrist, of Leeds University.

Mr. W. Stuart Miller, iron and steel merchant, Clarence Chambers, 4, Piccadilly, Manchester, has removed to 435 and 436, Royal Exchange Buildings, Manchester.

Mr. E. S. Andrews has entered into partnership with Major J. H. Beaumont as patent agents and consulting engineers at 204-6, Bank Chambers, 329, High Holborn, W.C.2.

The directors of the Vulcan Foundry Company, Limited, offer at par 50,000 ordinary shares of £1 each to shareholders in the proportion of one new share for every ten shares held.

The Northern Engineering and Construction Company, Limited, is being wound up voluntarily. Mr. T. Herdman, 3, Exchange Place, Middlesbrough, has been appointed liquidator.

Messrs. T. Perry and T. Pittaway, brass and iron founders, Excelsior Foundry, Fawdry Street, Birmingham, trading under the style of Perry & Company, have dissolved partnership.

The shareholders of the Metropolitan Associated Engineers, Limited, have decided to wind up the company voluntarily, with Mr. A. L. Sutcliffe, 10, Coleman Street, E.C., as liquidator.

The members of the Birmingham Metallurgical Society met at the Chamber of Commerce last month, when Mr. S. L. Archbutt presented a paper upon "Solidification in Metal Moulds."

The partnership heretofore subsisting between Messrs. A. Worrall and H. Newman, metal dealers, Pershore Street and Commercial Street, Birmingham, under the style of Worrall & Newman, has been dissolved.

The Consolidated Steel Corporation, of New York, have appointed Mr. C. M. Sanders, late of the firm of Sanders Bros. & Company, as their British agent. Mr. Sanders' office is at 139, Fenchurch Street, E.C.3.

The shareholders of the Pneumatic Tool Company, Limited, have decided that the company be wound up voluntarily. Mr. H. L. Williams, 70, Queen Victoria Street, London, E.C., has been appointed liquidator.

The partnership heretofore subsisting between Messrs. C. W. Collins, W. A. Winskill and R. Travis, engineers, 20, Brazennose Street, Manchester, under the style of Collins & Company, has been dissolved.

The metal business of Mr. J. E. Mapplebeck, of Birmingham, has been acquired by the Great Western Smelting & Refining Company, U.S.A. For the time being the business will be carried on at Frankfort Street, Birmingham.

The partnership heretofore subsisting between Messrs. W. L. Adams and H. R. Wade, engineers, Burton Street, Peterborough, under the style of the Laxtonia Engineering Company, has been dissolved, as far as regards Mr. H. R. Wade.

The capital of Dennis Brothers, Limited, has been increased to £600,000 by the creation of 300,000 £1 shares. A maximum of 110,000 of such shares have been placed at the disposal of the board to exchange for shares in White & Poppe, Limited.

The partnership heretofore subsisting between Messrs. F. C. J. Webster and E. A. Barton, engineers, trading under the style of the Reliance Engineering Company, at Holden Street, Mugglestone's Yard, Alfreton Road, Nottingham, has been dissolved.

The Canadian Engineering Standards Association has recently been incorporated at Montreal, the promoters including Sir John Kennedy, Dr. R. Ruttan, Dr. J. B. Porter, Mr. R. J. Durley, and Mr. H. H. Vaughan, all well-known in Canadian engineering circles.

Messrs. W. R. Williams & Company, steel and tool agents and merchants, 23, Wilson Street, Finsbury, London, E.C.2, have appointed Mr. J. H. Clements as their representative for export, and the north, north-western, south-western, and western districts of London.

The Springfield Steel Company, Limited, are rearranging the whole lay-out of the Springfield Foundry, Glasgow. A large new dressing shop is being built, extensive additions are being made to the foundry buildings, and much modern foundry plant is to be laid down.

Messrs. R. O. Ahlers and C. J. Head, consulting mining and metallurgical engineers, Norfolk House, Laurence Pountney Hill, E.C., trading as Ahlers & Company, have dissolved partnership. Mr. Head will carry on the business under the style of C. J. Head & Company.

The Victor Engineering Company, Limited, have established themselves in business, with offices and works at 18, Holland Street, Glasgow. The class of work carried out by this firm will be general engineering (small work), millwrighting, and electrical power work, A.C. and D.C. for collieries and factories.

In addition to the scheme of reconstruction and re-arrangement of their works at Elswick, Scotswood and Openshaw, we understand that Sir W. G. Armstrong, Whitworth & Company, Limited, have now definitely concluded an amalgamation with the Glasgow engineering firm of A. and J. Main & Company, Limited.

The North-East Coast Institution of Engineers

AND SHIPBUILDERS propose to admit ladies to membership. There will also be created a class of members known as "Honorary Fellows," and another class known as "Fellows," the former being such distinguished or learned persons as the Council may elect, and the latter ex-presidents or ex-vice-presidents of the Institution.

AT a meeting of the shareholders of Vickers, Limited, at Sheffield, on April 10, the resolutions to increase the capital by £13,000,000 to £26,500,000 were confirmed. The chairman (Mr. D. Vickers, M.P.) said he had that morning received a telegram from the Metropolitan Carriage, Wagon & Finance Company, Limited, stating that Vickers' offer had been accepted by three-quarters of their million shareholders.

MR. JOHN COLLINGS, of 36, Abbeyfield Road, Pitsmoor, Sheffield, has been appointed by the Victoria Brass Foundry, of Edinburgh, and the Oriental Tube Company, of West Bromwich, as their sole agent for Sheffield and district. Mr. Collins was connected with Cammell, Laird & Company, Limited, Sheffield, for 20 years, and for the past five years has held a responsible position with Thos. Firth & Sons, Limited, Sheffield.

AN offer for the purchase of a controlling interest in the Otis Steel Company, Limited, has been made by Messrs. William Salomon & Company, bankers, of New York. The offer comprises 120 net London terms for the preferred stock, and 210 net London terms for the common stock, ex the dividend paid on April 1. The final dividend on the common stock is 2½ per cent., with a 2½ per cent. bonus, making 12½ per cent. for the year.

THE BRITISH AIR BRAKE COMPANY, LIMITED, 15, Deans Yard, Westminster, London, S.W., has been formed for the manufacture of compressed air brakes, which will be made at the works of Messrs. G. D Peters & Company, Slough. The managing director is Mr. J. W. Cross, who during his business career has been associated with the London & North-Western Railway, the Great Western Railway, and the Westinghouse Brake Company.

DR. W. H. HATFIELD has been elected president of the Sheffield and District branch of the British Foundrymen's Association for the ensuing year, with Messrs. J. R. Hyde and J. Watson as vice-presidents. Messrs. F. Darley, T. Brown and J. A. E. Wells have been elected to vacancies on the committee, and Mr. A. Whiteley appointed hon. secretary and treasurer. At the last meeting an interesting paper describing difficulties experienced in making steel castings was given by Mr. F. Darley.

THE Home Secretary has made a regulation under Section 79 of the Factory and Workshop Act, 1901, in respect of the processes of crushing, grinding, and sieving of refractory materials containing not less than 80 per cent. of silica (SiO_2), and processes involving the manipulation of such materials in the manufacture of bricks or other articles containing not less than 80 per cent. of silica (SiO_2). The regulations apply to all factories and workshops, or parts thereof, in which these processes are carried on.

THE REDBOURN HILL IRON & COAL COMPANY, LIMITED, have produced 1,103 tons 18 cwts. of mild steel in one week from a 60-ton furnace, with an all-cold charge by machine. This is considered to be a record for this country. As it is of the utmost importance that good outputs should be secured to maintain the trade of the country, it may act as an incentive to other firms to publish these figures, and we shall be glad to publish better outputs if and when obtained. The furnace in question is one of four which Wellman, Seaver & Head, Limited, have supplied and built for the Redbourn Company.

RESOLUTIONS confirming an alteration in the articles of association and authorising the increasing of the capital of the company to £2,000,000 by the creation of 1,300,000 shares of £1, to rank as ordinary shares, and authorising the directors to issue 100,000 such shares at a price not less than par to any of the directors, officers, servants, workmen, or other employés of the company, and further authorising the capitalisation of £800,000 for distribution among the ordinary shareholders, were passed at a meeting of Hadfields, Limited, in Sheffield. The new ordinary shares are to be distributed in the proportion of two fully-paid shares for each ordinary share held.

CAMMELL, LAIRD & COMPANY, LIMITED, have carried out considerable extensions and improvements during the year, particularly at Penistone, where a large new Siemens steel works is approaching completion. Further extensions have also been put in hand. In order to provide for these latter extensions it is proposed to issue 45,907 ordinary shares, to be offered to existing ordinary shareholders at par in the proportion of one new share for every five shares held. The capital of the company is to be increased by £750,000 by the creation of 150,000 ordinary shares of £5 each, thus making the total authorised capital £3,250,000 divided into 400,000 ordinary shares, and 250,000 5 per cent. cumulative preference shares of £5 each.

THE following headings have been deleted from the list of prohibited exports:—(A) Copper, whether refined or unrefined, unwrought, wrought or partly wrought, of all kinds and descriptions, including brass, bronze, yellow metal and all other alloys of copper. (B) Engines for use on board ship (including Diesel and other internal combustion engines for marine propulsion) and component parts of such engines; (B) iron and steel castings and forgings for hulls and machinery for ships; (B) machinery for steam ships and components parts thereof; (B) ships' auxiliary machinery; (B) ships' telegraphs and component parts thereof; (B) steering gear and component parts thereof; (B) winches; (B) windlasses. The following heading has been added:—(A) Copper and alloys of copper.

THE BRITISH INDUSTRIAL CORPORATION, LIMITED, has been registered with a nominal capital of £1,000,000 in £1 shares, of which 200 are management shares. The ordinary shares rank first for a cumulative preferential dividend of 6 per cent. per annum. The objects are to establish or finance companies or associations for the promotion or execution of industrial and other undertakings, whether public or private. The first directors are:—Mr. T. Jowett, director of the Bengal Iron & Steel Company, Limited; Mr. N. E. Holder, vice-chairman, Russian Corporation; Mr. H. Steel, chairman of the United Steel Companies, Limited; Mr. W T. MacLellan, chairman of P. and W. MacLellan, Limited, and Mr. C. A. Bendix, Messrs. Haes & Sons. The registered office is at 24, Throgmorton Street, E.C.

THE Secretary of the Ministry of Munitions announces that as it has now become possible to close the Priority Department of the Ministry, Lieutenant-Colonel Alan H. Burgoyne, M.P., relinquishes the position of Controller of that Department, to which he was appointed in July, 1918. Mr. Arnold B. Gridley has given up his position as Director of Electric Power Supply, but will act temporarily as Electrical Adviser to the Ministry, pending the liquidation of electrical contracts and the disposal of outstanding matters under negotiation. As we have already announced, Mr. W. T. Layton has resigned his position as a member of the Munitions Council on his appointment as Director of the National Federation of Iron and Steel Manufacturers. Mr. Layton will, however, continue in an honorary capacity to complete certain undertakings with which he was associated in the Ministry.

TAYLOR BROTHERS, LIMITED, announce that they have decided upon a large extension of their premises and business at Trafford Park, Manchester. This decision is principally due to the fact that the rates of Leeds are higher and that opportunities for extension in that city are fewer, owing to the severe building restrictions which are imposed. It was also largely due to these facts that, in the first place, some eleven years ago,

the firm decided to build new works at Trafford Park rather than extend their factories in Leeds. For some time difficulty has been experienced in the housing of the Manchester employés, but this is being overcome by a scheme which includes the building of a model village of about 400 houses on a piece of land 40 acres in extent in Davyhulme. It will be remembered that the firm have recently been amalgamated with the Metropolitan Carriage, Wagon and Finance Company, Limited.

THE TECHNICAL INSPECTION ASSOCIATION, which has recently been formed, should appeal to many technical men throughout the empire who are in any way interested in inspection work. It is the outcome of the Ministry of Munitions Inspection Department, and has been formed for two main purposes.—(1) To maintain intercourse and promote mutual assistance among its members; (2) to conserve and co-ordinate for the national use the experience brought together by the war, and generally to develop the progress and standardisation of inspection in the engineering, chemical and allied industries. It is intended in the near future to make arrangements for series of meetings at which papers on subjects connected with inspection will be read and discussed. One of the objects of the Association will be to introduce uniformity of method amongst its members. Until permanent offices can be arranged the address of the hon. secretary of the Association, Mr. W. H. Smith, will be the Hotel Metropole, Northumberland Avenue, London, W.C.2.

THE British Scientific Products Exhibition, organised by the British Science Guild, will be open at the Central Hall, Westminster, from July 3 to August 5 next. The Organising Committee includes Professor R. A. Gregory (Chairman), Mr. E. C. Barton, Sir Robert Hadfield, Bart., Mr. Robert Mond, Professor G. T. Morgan, Bt. Lt.-Col. W. A. J. O'Meara, and the Hon. Sir Charles Parsons. The secretary is Mr. F. S. Spiers, 82, Victoria Street, London. S.W.1. It will be remembered that a similar exhibition was held at King's College last summer, while there was a more recent one at the College of Technology, Manchester. The objects are to illustrate recent progress in British science and invention and to help the establishment and development of new British industries. The exhibits will be divided into sections, including aircraft, chemistry, education, electrical appliances, engineering (prime mover, traction, mechanical devices and models), fuels (solid, liquid and gaseous), metallurgy (ferrous products, non-ferrous products, furnaces and plant), and physics. Arrangements are also being made for lectures, conferences, and demonstrations.

STEEL CASTINGS, LIMITED, are making additions to their Parkhead Works, Glasgow, which when completed will enable them to at least double their present output. The foundry is being extended, and a Siemens 15-ton open-hearth melting furnace is being put down, complete with producers and auxiliaries. Drying stoves of a somewhat novel design are in course of building, and an additional 5-ton electric crane is to be installed for serving the light bay in the foundry. Necessary additions are being made to the dressing shop, and these will be served by a 3-ton electric crane. An entirely new annealing shop is being erected, which will be equipped on the most modern lines and will be served by an independent producer plant. A 15-ton electric crane is to be installed, and the shop is so designed that it may be extended with a minimum of labour at a future date. A house is in course of erection for the reception of a pair of compressors for supplying pressure for the pneumatic tools, the installation of which is to be considerably extended. The whole of the works will be electrically driven, power being taken from the Glasgow Corporation, and the necessary extensions are being made to the works sub-station. New railway sidings are being laid, and, in fact, the whole works are being rearranged. The complete change-over will occupy some time, as the work has to be carried out without interfering with the present output of the foundry. An interesting feature in the dressing shop is the cutting off of many of the risers with an electric arc. Of course this system is not generally employed, but only where the riser is not accessible to the saw and as an alternative to the Oxy-Acetylene process for parts requiring after-machining. The actual cutting is, needless to say, more costly than the Oxy-Acetylene process, but then whereas with the last-named it is customary to leave about ½ in. for chipping, on account of the hard skin produced by the process, no such hardening effect is brought about by the electric arc cutting, which can therefore be done so as to reduce after chipping to the narrowest margin. For cutting, a pure graphite electrode is used, and risers up to 8 in. sq. have been removed by the process.

THE MACHINE TOOL TRADES' ASSOCIATION was registered on April 10 as a company limited by guarantee to provide a central national organisation for the support, protection, and furtherance of the interests of manufacturers and others connected with the British machine tool trade. The first members of the Council are:—Sir Alfred Herbert, K.B.E., Dunley Manor, Whitchurch; J. W. S. Asquith (William Asquith, Limited, Halifax), Hants; J. Darling (Darling & Sellers, Limited, Airedale Works, Keighley); A. Drummond (Drummond Bros., Ryde's Hill, Guildford); E. M. Griffiths (Burton, Griffiths & Company, Ludgate Square, E.C.); H. A. Ibbert (J. Holroyd & Company, Limited, Perseverance Works, Milnrow); W. Deakin (Machinists, Limited, 41-43, Oozells Street, Birmingham); S. H. March (Churchill & Company, 6, Oxford Street, Manchester); E. Parkinson, O.B.E. (J. Parkinson & Son, Shipley); W. G. Shanks (T. Shanks & Company, Union Iron Works, Johnstone, nr. Glasgow); J. D. Steven (E. G. Rigley & Company, 28, Victoria Street, S.W.1); R. Stirk (J. Stirk & Sons, Limited, Ovenden Road, Halifax); H. Butler (J. Butler & Company, Victoria Iron Works, Halifax); R. W. Cunliffe (Cunliffe & Croon, Limited, Broughton Iron Works, Manchester); Col. O. C. Armstrong, D.S.O. (Greenwood & Batley, Limited, Leeds); W. A. Jones (W. A. Jones & Shipman, Limited, New Century Works, Leicester); J. R. C. Kearns (H. W. Kearns & Company, Limited, Manchester); A. Denton (C. Redman & Sons, Pioneer Ironworks, Parkinson Lane, Halifax); W. Swift (G. Swift & Sons, Claremont Ironworks, Halifax); W. L. Taylor (Charles Taylor, Birmingham, Limited); J. Elles Brown (D & J. Tullis, Limited, Sardinia House, W.C.); C. Wicksteed (C. Wicksteed & Company, Kettering); W. F. Clark (J. Archdale & Company, Limited, Ledsam Street, Birmingham); E. Russell Brayshaw (Brayshaw Furnaces & Tools, Limited, Hulme, Manchester); A. L. Churchill (C. Churchill & Company, Leonard Street, E.C.9); J. Judson (The Judson Jackson Company, Limited, 50, Marsham Street, S.W.); A. H. Baldwin (Kendall & Gent, Limited, Gorton, Manchester); Provost W. B. Lang (J. Lang & Son, Johnstone, nr. Glasgow); L. F. Massey (B. & S. Massey, Limited, Openshaw, Manchester); F. Pollard (F. Pollard & Company, Leicester); A. E. Matheson (G. Richards & Company, Limited, Broadheath, Manchester); C. J. Robinson (T. Robinson & Son, Limited, Rochdale).

THE export steel and tool trades came under review at the meetings of the Association of British Chambers of Commerce. Mr. W. F. Beardshaw (Sheffield) moved:—"That the Association desires to draw the attention of his Majesty's Government to the restrictions, amounting to prohibition, which are being placed on the steel and tool and textile industries by the Allied Governments; the prohibition taking the form of a refusal to grant licences for importation. That this matter is seriously prejudicing the future of British trade, and leading to unemployment at a very critical time, and that the Government be urged to make strong representations on the matter to the French and Italian authorities." Mr. Beardshaw remarked that Sheffield

had done its best individually to get the restriction removed. It was important to have representations made to our Allied Governments to give some consideration with regard to our export of steel and tools which were so necessary to assist in reconstruction in Allied countries. They knew quite well that Sheffield had been second to none in extending their plants in order to make the necessary munitions for the war, and they had often extended those plants quite regardless of costs and their future trade. Now the time had come when there was no more demand for these plants in Sheffield by the Government, but there was a considerable demand in France and Italy. They were held up in these countries by the restrictions which they were unable to deal with. The British Government was quite willing to give them export facilities, but the French and Italian Governments were refusing terms and making it impossible for their people to purchase these articles. Mr. E. A. Beazley, British Chamber of Commerce in Paris, said at the present moment France was in a state of chaos so far as trade was concerned. The Sheffield Chamber had, since the Armistice, been able to do something in the way of obtaining certain allocations for high-speed steel, etc., but the promise had not yet been fulfilled. Recently the French Government had raised the importation restrictions on steel and small tools, but this concession had been based on the imports of 1917, when the United States of America was in quite a different state to Great Britain. Her exports at that moment were right up, whereas they in England were all working for the Government, and could send very little into France. He thought the 1917 basis was most unfair. Whilst he supported the resolution, he however, said that for diplomatic and friendly reasons he would like to see the words "French and Italian Governments" left out, and "Allied Governments" substituted. The resolution was carried.

Vickers-Petters, Limited.

An announcement has been made by the directors of Petters, Limited, to the effect that they have entered into an agreement with Vickers, Limited, for a combination of interests in the Petter patent semi-Diesel oil engines. The extensions in the company's works at Yeovil have been mainly for aircraft construction, and for the economical production of these heavy engines the situation of Yeovil is unsuitable. During the war Vickers, Limited, acquired the Diesel Works at Ipswich, which have facilities for the economical manufacture of these engines. A subsidiary company is being formed with a capital of £500,000 in 320,000 ordinary shares and 180,000 6 per cent. cumulative preference shares. In this company Vickers & Petters will be the sole shareholders. Vickers transfer the freehold works at Ipswich and Petters transfer all patterns, special tools, etc., for the construction of the Petter semi-Diesel oil engines, together with all stock on hand, work in progress, and orders at March 31, 1919.

Petters' share interest will be 159,900 ordinary shares and 55,000 preference shares. The name of the new company is Vickers-Petters, Limited, and it commenced operations on April 1, with a large number of orders on hand and a cash working capital of £100,000. Petters will have three directors out of seven, and Mr. E. W. Petter is managing director for five years. It is expected that not only will the manufacturing facilities be greatly increased, but the advantages from Messrs. Vickers' commercial organisation will be of considerable importance. The directors look to the future with great hope and expectation

The works at Yeovil remain the property of the company, which will continue the manufacture of its varied engineering specialities. It is intended to manufacture small sizes of oil engines in large quantities by specialised methods, and the directors anticipate being able to keep the works occupied to their full extent.

Parliamentary Notes.

Industrial Insurance.

MR. BRIDGEMAN has informed Sir M. Barlow that it has been decided to appoint a committee to inquire into industrial insurance, but the terms of reference have not yet been definitely settled.

Trade Union Practices.

The text is issued of the Bill introduced by the Minister of Labour for restoring trade union practices which have been in abeyance during the war. The principal clause reads substantially as follows:—Where in any establishment to which this Act applies any rule, practice, or custom obtaining before the war in any industry or branch of an industry has, during and in consequence of the war, been departed from, the owner of that establishment shall be under an obligation, at the expiration of one month from the date when the prescribed notice is served on him, to restore or permit the restoration of the trade practice so previously obtaining, and for one year after such restoraton is effected to maintain or permit the continuance of the trade practice.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Aston, W. H. Crucible furnaces. 8,777. April 7.
Beardsley, E. O., and Piper, W. F. Apparatus for making moulds for casting. 7,549. March 26.
Beardsley, E. O., and Piper, W. F. Method of making moulds for casting. 7,550. March 26.
Barkes, H., Besford, H. J., and Day, T. J. Solder for aluminium, etc. 8,667. April 5.
Barkes, H. Besford, H. J., and Day, T. J. Tools for soldering aluminium, etc. 8,666. April 5.
Bastian, C. O. Determining decalescent point of steel. 7,482. March 25.
Brand, J. J. C. Apparatus for firing furnaces with powdered fuel. 6,055. March 11.
Clarke, A. B. Alloy of aluminium. 7,128. March 21.
Coldwell, C. B. Metal-casting moulds. 6,487. March 15.
Danson, F. H. Apparatus for cleaning tuyères and/or tapping holes of blast, cupola, Siemens, etc., furnaces. 7,759. March 28.
Dear, C. Oil-hardening steel plates. 5,744. March 7.
Dear, C. Nickel-steel alloys. 5,745. March 7.
Dendrinos, A. A. Method for protecting iron, steel, etc., from oxidation when heated to a high temperature. 4,857. February 26.
Eichberger, A. L., and Pressure Casting Company. Casting metals 9,164. April 10.
Gibson, W. Patterns for making moulds for metals. 9,365. April 12.
Gray, R., and Wellman, Seaver & Head. Steel making, etc., furnaces or mixers. 8,890. April 8.
Gregg, H. H. Alloy of aluminium. 7,128. March 21.
Grocott, F. J. Melting-furnaces burning producer gas. 6,929. March 20.
Hole, I. Electric smelting furnaces. 5,573. March 6. (Norway, April 11, '18.)
Joly, J. Method of separating alloys or mixtures of metals. 7,767. March 28.
Leopard, E. A. Solder for aluminium and its alloys. 6,985 March 20.
Mathy, M. Rocking crucible furnaces. 4,482. February 22.
Mole, L. B. de. Casting metals. 6,975. March 20.
Oxley, G. H., and W. Foundry ladles. 8,594. April 5.
Rogers, F. Steel for resisting corrosion and high temperatures. 6,824. March 19.
Smith, C. H. Furnaces. 8,445. April 3. (United States, April 3, '18.)
South Durham Steel & Iron Company and Williams, T. Nozzles for casting ladles. 8,096. March 31.
Stabilimenti Biak—Ing. A. Pouchain. Metal alloy containing manganese. 6,986. March 20.
Stock, G. J. Manufacture of grey iron. 4,082. February 19.
Stokes Castings, Limited, and Stokes, F. W. Moulds or chills. 9,400. April 12.
Swift, T. Collapsible cores for casting metal articles. 8,384. April 3
Tidswell, H. R. Method of casting aluminium on to wrought iron or steel. 8,280. April 2.
Waterbury Farrel Foundry & Machine Company. Trimming metal blanks. 9,350. 9,351. April 12.
Webster, W. G. Method of malleablising cast metal. 6,210. March 12.
Whittle, J. A., & R. W. Weighing device for cranes, etc. 8,729. April 7.

Deaths.

THE death is announced of Mr. J. Thomson, iron merchant, Arbroath.

MR. W. BUTTLE, cashier to the Carnforth Hematite Iron Company, Limited, died last month, after 40 years' service with the firm.

THE death is announced in the German papers of Dr. Ehrenfried Corleis, the head of the Krupp Chemical and Testing Laboratories at Essen.

MR. T. TAYLOR HARVEY, formerly steelworks manager to Palmers Shipbuilding & Iron Company, Limited, died last month, at the age of 72 years.

MR. JOSEPH E. JOHNSON, JUN., the well-known American author of treatises on blast-furnace construction and working, was accidentally killed by a motor-car on April 4. He was 49 years of age.

THE death has occurred, at his residence at Southsea, of Sir Thomas Mitchell, who was manager of the Constructive Department of Portsmouth Dockyard when the first Dreadnought was built. Sir Thomas, who was 75 years of age, started life as a shipwright apprentice in Chatham Dockyard.

MR. G. RODGER, consulting engineer, of Sheffield, died recently. Mr. Rodger had been in the shipyards on the Clyde and Barrow, and went to Sheffield about 35 years ago. He was with Wm. Jessop & Company, Limited, for about 20 years, and subsequently was a consulting engineer on his own account.

THE death took place on April 17, at Brighton, of Mr. W. J. Lineham, M.I.M.E., M.I.C.E., M.I.E.E., of Jesmond, Lee, Kent, aged 60 years. The deceased gentleman, who was a native of Leeds, was head of the engineering department of the Goldsmiths' College, University of London, and was the author of several standard text-books on engineering.

THE death occurred suddenly on April 23 of Lieut.-Colonel Sir Archibald Dawnay, who was serving his eleventh consecutive year of office as Mayor of Wandsworth. Sir Archibald, who was 76 years of age, was a civil engineer by profession, and head of the firm of Archibald D. Dawnay & Sons, Limited, Steelworks Road, Battersea, London, S.W., and the Girder Works, East Moors, Cardiff.

MR. H. MCCARTER JOEL died at his residence, Woodside House, Brincliffe, Sheffield, last month. The deceased gentleman was born in 1837, and at an early age commenced business on his own account as a file manufacturer. Subsequently he started the Well Meadow Works, Allen Street, as an iron and steel manufacturer. From that time he never looked back, and finally retired from business three years ago.

WE regret to announce that Sir William Crookes, the distinguished scientist, died on April 4 at his residence in Kensington Park Gardens, at the age of 86. He was born on June 17, 1832, and entered the Royal College of Chemical Science at the age of seventeen, becoming at twenty an assistant to Dr. Hoffmann, who was one of the pioneers in England of the work at the coal-tar dyes. Young Crookes for a time pursued his investigations in this branch of commercial chemistry, and among his contributions to chemical literature are several books and translations relating to the aniline dyes. He was, however, more devoted to pure chemistry, and successive appointments to the Meteorological Observatory at Oxford and to the Professorship of Chemistry at the Training College at Chester definitely directed his career on the new lines. It was however, while he was investigating some of the waste products of the sulphuric acid which is used in dyeing that he was led to the discovery of the new metallic element thallium. This was made in 1861, and helped to win him his Fellowship of the Royal Society. He founded the "Chemical News" in 1859, was knighted in 1897, received the Order of Merit in 1910, and was elected President of the Royal Society in 1913. Among his other discoveries were the radiometer and the spinthariscope His invention, the Crookes tube, enabled Professor Rontgen to discover the X-rays.

Personal.

SIR THOMAS WRIGHTSON, Bt., recently reached his 80th birthday.

SIR CECIL L. BUDD has been elected a director of Muntz's Metal Company, Limited.

THE late Mr. C. Tildesley, lock manufacturer, of Willenhall, left estate of the gross value of £47,210.

THE Right Hon. Viscount Peel has resigned his seat on the board of Head, Wrightson & Company, Limited.

DR. J. S. BRIDGES has been nominated for the Senate of the London University in the Faculty of Science.

THE gross value of the estate of the late Mr. W. T. Thompson, of Birmingham, brassfounder, etc., is £13,083.

THE late Mr. C. W. Taylor, of Manor House, Westoe, South Shields, engineer and ironfounder, left £196,311.

MR. H. E. STILGOE, of Birmingham, has been appointed chief engineer to the Metropolitan Water Board.

THE late Mr. J. Readhead, the younger, of Trewchitt Hall, Rothbury, Northumberland, retired shipbuilder, left £11,691.

THE late Mr. T. Norton, of Messrs. Norton, Owen & Company, metal merchants, 6, Great Winchester Street, E.C., left £28,837.

THE late Mr. A. W. Robertson, of the Lea Shipbuilding Yard, West Ham, left real and personal estate of the value of £140,127.

MR. C. PAYNE, Director of National Shipbuilding, has resigned to resume his duties as managing director of Harland & Wolff, Limited.

THE late Mr. J. A. Innis, a director of Wigham, Richardson & Company, Limited, left estate valued at £51,170, with net personalty £51,137.

MR. W. CLARK, who has been elected vice-president of the Sheffield Chamber of Commerce, will be succeeded on the council by Mr. P. MacGregor.

MR. F. W. CLAYTON, manager of the saw department at the Ætna Works, Sheffield, of Spear & Jackson, Limited, has resigned to take up work abroad.

MR. E. DOXFORD, of Wm. Doxford & Sons, Limited, is to succeed Mr. E. L. Orde as president of the North-East Coast Institution of Engineers and Shipbuilders.

MR. D. D. WALKER, managing director of the D. D. Walker Company, Limited, machinery merchants, etc., 28, Budge Row, London, E.C.4, has resigned and has been succeeded by Mr. F. R. Maddox.

MR. C. W. HUNT has been appointed Lancashire branch manager of the Associated British Machine Tool Makers, Limited, with headquarters at Lloyds Bank Buildings, King Street, Manchester.

MR. A. SHUTTLEWORTH, chairman of Clayton & Shuttleworth, Limited, has retired from the board, after 50 years' continuous connection with the business. Mr. A. C. Newsum has also retired. Mr. P. W. Robson has been elected chairman.

THE Chair of Mechanism and Applied Mechanics rendered vacant at Cambridge by the death of Professor Bertram Hopkinson has been filled by the appointment of Mr. C. E. Inglis, Fellow of King's College and University Lecturer in Mechanical Engineering.

MR. W. T. LAYTON, a member of the Council of the Ministry of Munitions, has been appointed Director of the National Federation of Iron and Steel Manufacturers. Mr. Layton will continue for the present to represent the Minister of Munitions on the Supreme Economic Council in Paris.

CAPTAIN S. K. WATSON and Lieut. W. A. Sycamore, both on the staff of the British Westinghouse Electric & Manufacturing Company, Limited, are joining the Keighley Gas & Oil Engine Company, Limited, the former as salesman in the Yorkshire District, and the latter as selling engineer in London.

THE Governors of the Imperial Mineral Resources Bureau have appointed Major W. M. Henderson-Scott to be secretary of the Bureau in place of Mr. A. D.

MOULDING MACHINES

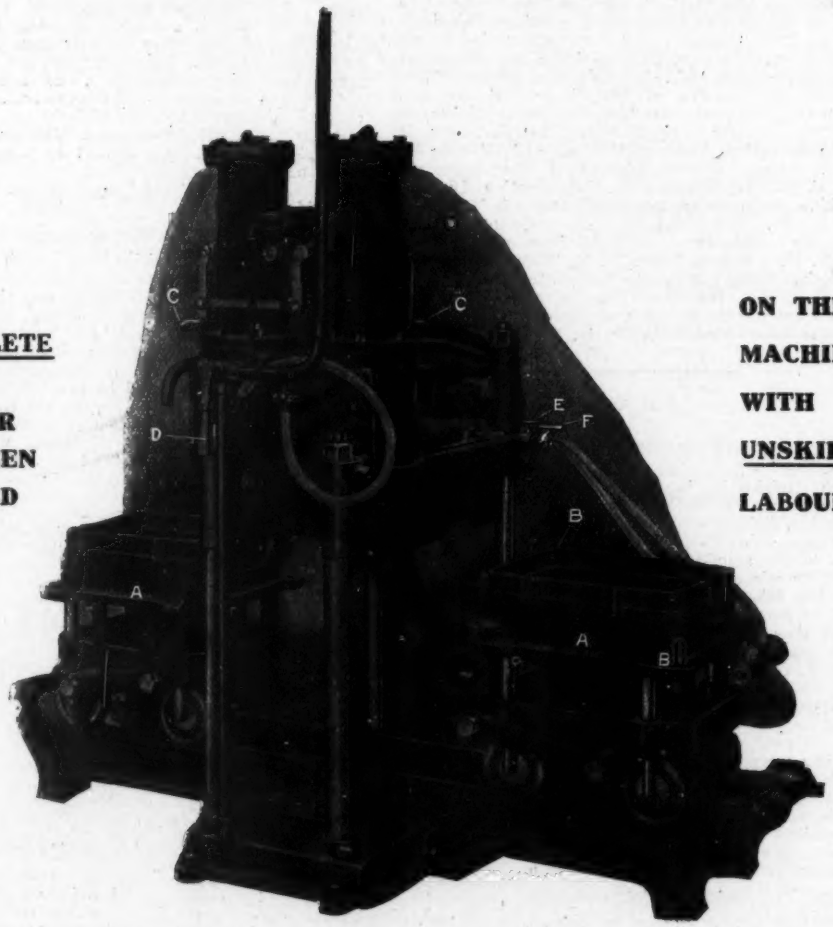
OF EVERY DESCRIPTION.

Pneumatic, Hydraulic, Jar Ramming, & Hand Power.

Type "A" Duplex Machine for Pneumatic Power.

Fitted with self-adjusting Rammer Head which accommodates itself to any varying depth of pattern.

OVER 50 COMPLETE MOULDS PER HOUR HAVE BEEN PRODUCED



ON THIS MACHINE WITH UNSKILLED LABOUR.

One of many that we have installed in various Munition Work Centres.

JAMES EVANS & CO., BRITANNIA WORKS, BLACKFRIARS, MANCHESTER.

McNair, who has resigned the appointment of organising secretary.

THE KING has granted permission to the undermentioned to wear the following decorations, which have been conferred in recognition of valuable services rendered :—Decorations conferred by His Majesty the King of Italy :—Order of the Crown of Italy.—Commander.—Sir Arthur Duckham, K.C.B., and Sir Glynn Hamilton West. Officer.—Sir Daniel Macaulay Stevenson, Bt. Decorations conferred by His Majesty the King of the Belgians :—Order of the Crown.—Commander.—Sir Charles Edward Ellis, K.C.B., late Representative of the Ministry of Munitions in Paris; Sir Frederick William Black, K.C.B., late Director-General of Munitions Supply, Ministry of Munitions; and Mr. Maurice Sylvester Gibb, Representative of the Ministry of Munitions, National Projectile Factory, Birtley. Order of Leopold.—Officer.—Mr. William Turner MacLellan, C.B.E., J.P., late Assistant Controller, Iron and Steel Production Department, Ministry of Munitions; Sir Leonard Wilkinson Llewelyn, K.B.E., late Controller, Non-Ferrous Materials Supply Department, Ministry of Munitions; Sir Alfred Edward Herbert, K.B.E., late Director, Machine Tools Department, Ministry of Munitions; and Sir John Hunter, K.B.E., late Member of Council, Ministry of Munitions. Order of the Crown.—Chevalier.—Mr. H. W. Letts-Naylor, Assistant Controller of Salvage; Mr. T. B. Barker, Deputy Director of Raw Materials; Mr. F. E. Bagnall, O.B.E., late Section Director, Machine Tools Department, Ministry of Munitions; Mr. R. W. Dana, O.B.E., late Assistant Director, Ordnance Supply Department, Ministry of Munitions; Mr. E. H. Crush and Mr. N. G. Thomas, Assistants Explosives Supply Department, Ministry of Munitions; Mr. R. Wake, Inspector, Small Arms and Machine Guns Department, Ministry of Munitions; Mr. J. S. Waters, Supervisor of Contracts, National Projectile Factory, Birtley.

Legal.

Elton, Levy and Company v. Williams & Foulds.

Mr. Justice Salter has given judgment in the King's Bench Division in the action by Messrs. Elton, Levy & Company, Birmingham, against Messrs. Williams & Foulds, Britannia Wharf, Birmingham. The plaintiffs claimed damages for alleged breach of a contract in the supply of caster's ashes and bosh dirt. Plaintiffs alleged that it was a term of the contract that the ashes should contain not less than 8 per cent. of copper. Defendants delivered 193 tons, for which they were paid £495, and it was stated that these ashes did not contain more than 4 per cent. copper. In regard to the bosh dirt, the plaintiffs' contention was that there was a warranty for 17 per cent. copper, the price being £8 per ton, and that the percentage of copper in the quantity supplied was only 10 per cent. The defendants denied that there was any warranty regarding the percentage of copper.

His Lordship said he was satisfied that there was a warranty that the goods should equal in quality those which were the subject of an earlier sale. Plaintiffs had failed to satisfy him that the warranty was broken. He therefore entered judgment for the defendants. Notice of appeal was given.

Nickel Condemned by Prize Court.

In the Prize Court recently the President, Lord Sterndale, condemned as contraband large quantities of copper and nickel, laden on the steamships "Hero," "Zamora," "Augusta," and "Sydland," and consigned from New York to Stockholm, but which the Crown alleged were intended for enemy countries. The President said it was not disputed that shipments had been made by the shippers without any knowledge on their part that the goods were intended for enemy countries. A claim was made to the metal by the Swedish Trading Company, but they withdrew the claim before the trial. The withdrawal of the claim could only have been because it was recognised that no answer could be given to the case of the Crown. If reliance could not be placed on the bone-fides of statements put forward on behalf of a company whose directors were gentlemen of high commercial and public positions, belligerents were compelled to exercise a more rigorous investigation into suspected cases of contraband, and more inconvenience was inflicted upon neutrals than would otherwise be necessary.

Green and Company v. Hafter.

The claim of T. Green & Company, Cosley Foundry, Bilston, against A. Hafter (London) for £227 15s. for goods sold and delivered, came before Mr. Justice Sankey in the King's Bench Division on April 3.

Counsel said the original claim had by reason of allowances been reduced to £179 14s., and he asked for judgment for that amount. The contract rose out of the manufacture of castings for 18-pounder shrapnel shells. The defendant asked plaintiff to supply him with 2,000 weekly, and when plaintiff had supplied him with a large number the defendant suddenly cancelled the contract. The defendant put in a defence alleging defective workmanship, and that delivery was not given in accordance with the contract. He counter-claimed for a sum which the plaintiff had allowed, and also claimed £100 as damages. He was ordered to give particulars of defects that he alleged, and had not done so.

His Lordship entered judgment for plaintiff for £179 14s. and costs.

Stobie v. Newcastle Electric Supply Co.

In the Chancery Division, last month, Mr. Justice Peterson had before him a dispute between Mr. V. Stobie, of Sheffield and Dunston, and the Newcastle-upon-Tyne Electric Supply Company, Limited.

Defendants' counsel said the real question was whether Mr. Stobie could get out of the agreement. Mr. Stobie had invented a new furnace with which he was anxious to experiment, and he had not got the money to do it. Consequently he approached the defendants. On the construction of the documents counsel asked his lordship to say that the agreement with regard to profit charge, etc., did not expire until the end of the lease of the premises, and that in the circumstances this was a perfectly fair and proper working arrangement.

Plaintiff's counsel stated that the short point was whether or not, upon the construction of certain agreements, the defendant company was entitled to a share in the profits of Mr. Stobie's Dunston business and a certain control over the business. The case for Mr. Stobie was that, every penny advanced by the company having been paid off with interest, he was entitled to the benefits of the business free from any claim by the defendant company. Mr. Upjohn read the agreements between the parties, and argued that they could not possibly mean that the defendant company was entitled to a share of profits in respect of working capital or other advances which had been paid off. In the alternative he submitted that the contracts were unconscionable and should be set aside.

Cold Blast Pig-Iron.

A further announcement has been made recently in regard to cold-blast pig. The Minister of Munitions states that, in consequence of an arrangement with the manufacturers whereby certain existing subsidies payable on cold blast have been, or are to be, withdrawn, he has authorised an advance of 11s. per ton in the maximum price, to take effect on and after April 1, 1919. This advance, added to the increase of 15s. which took effect on January 1, will raise the maximum price for home sales to £10 8s. 6d. per ton, f.o.t. makers' works.

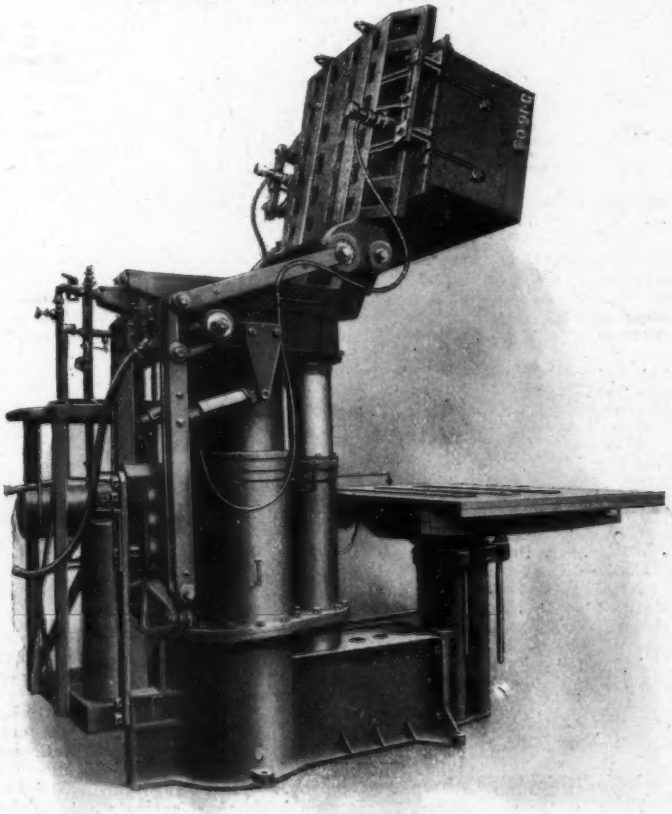
The export price remains unchanged at £11 12s. 6d. per ton, but the export drawback will be reduced by the amount of the increase in the home price.

MACNAB & Co.,

56/8, Eagle Street, Southampton Row, LONDON, W.C.1.

Tabor Combination Shockless Jar Ramming Power Roll-over and Pattern Drawing Moulding Machine.

Suitable for the most economical production of any repetition work from the smallest up to a load of 12,000 lbs. at 100 lbs. air pressure, covered by a range of five machines.



Mould having been rammed, box and pattern in act of being rolled over on to levelling table on other side of machine.

Jar rams the box in less than one minute.

Rolls the mould over, draws and raps the pattern.

Rolls the pattern back ready for the next box.

COMPLETE MECHANICAL OPERATIONS OF THE MACHINE NOT EXCEEDING FOUR MINUTES.

New Companies.

Machinery & Steels, Limited.—Capital £20,000 in £1 shares.

Trident Engineering Company, Limited.—Capital £10,000 in £1 shares.

Cycloid Engineering Company, Limited. — Capital £2,000 in £1 shares.

West Hydraulic Engineering Company, Limited.—Capital £40,000 in £1 shares.

Ferro-Arc Welding Company, Limited. — Capital £10,050 in £1 and 1s. shares.

F. H. Eve & Davie, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers.

J. F. & R. Platt, Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers.

Denny Chemical Engineering Company, Limited.—Capital, £50,000 in £1 shares (2,000 deferred).

Vallance & Jones, Limited.—Capital £3,000 in £1 shares, to carry on business as brass casters, etc.

Star Iron Works, Limited.—Capital £10,000 in £1 shares. Registered office:—Greenacres Road, Oldham.

Mulliners, Limited.—Capital £50,000 in £1 shares, to take over the engineering, etc., business of Mulliners, Limited.

Thornvill & Washam (1919), Limited. — Capital £30,000 in £1 shares, to carry on the business of engineers.

Dunkerley & Broadbent, Limited.—Capital £3,000 in £1 shares, to carry on the business of ventilating, etc., engineers

Greenwich Steel & Iron Works, Limited.—Capital £1,000 in £1 shares. Registered office:—27, Mincing Lane, E.C.

Burnett, Compton & Company, Limited. — Capital £20,000 in £1 shares, to carry on the business of iron workers, etc.

Acetrical Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office:—2, Hamilton Street, Greenock.

Standard Pliers, Limited.—Capital £5,000 in £1 shares. Permanent directors: F. C. A. Donovan and P. H. R. Vicary.

Scottish Metal Working Company, Limited.—Capital £3,000 in £1 shares. Registered office:—42, Lockerbie Road, Dumfries.

Concrete, Limited.—Capital £10,000 in £1 shares. Registered office:—Lincoln's Inn Chambers, 40, Chancery Lane, W.C.

Stanfield (Cosmos), Limited.—Capital £35,000 in £1 shares (15,000 preference), to carry on the business of engineers, etc.

Wedmore Engineering Company, Limited.—Capital £5,000 in £1 shares. First directors:—G. H. Beabon and W. Johnstone.

Nene Engineering Company, Limited. — Capital £10,000 in £1 shares. First directors:—J. H. Keeble and R. M. Boothman.

John M. Wilson (Motor Engineers), Limited.—Capital £5,000 in £1 shares. Registered office:—157, St Vincent Street, Glasgow.

G. W. Pearce & Sons (Brassfounders), Limited. — Capital £5,000 in £1 shares. Registered office: 94, Aston Road, Birmingham.

W. H. Surtees, Limited.—Capital £10,000 in £1 shares, to carry on the business of brassfounders. Registered office: Sunderland.

Springfield Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office:—Springfield Works, Dickenson Street, Salford.

Marston Billington, Limited.—Capital £50,000 in £1 shares, to carry on the business of ironfounders. Registered office:—23, King Street, E.C.

Hayter, Limited—Capital £10,000 in £1 shares, to carry on the business of ironfounders, etc. First directors:—G. Idiens and W. H. Hayter.

John B. Reid, Limited.—Capital £10,000 in £1 shares, to carry on business as engineers. Registered office:—Gaskell Street, Newton Heath, Manchester

Thornewill & Warham (1919), Limited.—Capital £30,000 in £1 shares, to acquire the existing business of engineers, etc., carried on at Burton-on-Trent.

Helmes McCreath, Limited.—Capital £3,000 in £1 shares, to carry on business of engineers, etc. Registered office:—Norwich House, High Holborn, W.C.2.

Donald H. Scott & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of steel merchants. Registered office:—23, Leadenhall Street, E.C.

Chandler, Dixon & Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of engineers, etc. Registered office:—39, Granville House, Arundel Street, W.C.2.

J. W. Newton, Sons & Company, Limited.—Capital £5,000 in 1,000 A shares of £1 each, and 8,000 B shares of 10s. each, to carry on the business of agricultural engineers.

McBride & Gray, Limited.—Capital £70,000 in £1 shares, to carry on the business of ship constructors and repairers. Registered office:—156, St. Vincent Street, Glasgow.

Ostroyd Engineering Company, Limited.—Capital £500 in £1 shares, to acquire the engineering business carried on by H. Ostrovsky at 34, Aylesbury Street, Clerkenwell.

Ferguson & Bruty, Limited.—Capital £2,000 in £1 shares, to carry on the business of ironfounders, etc. First directors: A. O. Ferguson, A. G. Bruty, and A. J. Ferguson.

Olliver & Addis, Limited.—Capital £1,500 in £1 shares, to take over the engineering business carried on by E. J. Olliver and H. W. Addis at 47, Eaton Road, Margate.

H. Osman & Company, Limited.—Capital £10,000 in £1 shares, to take over the business of H. Osman & Company, iron and steel merchants, etc., 165-6, Aldersgate Street, E.C.

E. A. Cooke, Limited.—Capital £6,000 in £1 shares, to acquire the business of brass and iron founders, etc., carried on by E. A. Cooke at Reliance Works, Bath Row, Birmingham.

Williams Engineering Company, Limited.—Capital £12,000 in £1 shares. First directors: H. W. Dole and V. S. Williams. Registered office:—Avenue Chambers, Southampton Row, W.C.

East Fife Shipbuilding Company, Limited.—Capital £2,000 in £1 shares. First directors: J. Appleck, L. Bruce, and A. Farrell. Registered office:—The Harbour, Anstruther, Fifeshire.

Three Counties Engineering Company, Limited.—Capital £50,000 in 45,000 preference shares of £1, and 100,000 deferred ordinary shares of 1s.. Registered office:—32, Charing Cross, S.W.1.

Bowen & Company, Limited.—Capital £10,000 in £1 shares (4,000 5 per cent. preference), to carry on the business of ironfounders. Registered office:—Phœnix Foundry, 6, Mount Pleasant, London, E.C

Fluxio Welding Company, Limited.—Capital £5,000 in £1 shares. First directors: T. A. Cotton, J. P. Schofield, and Dr. H. E. Cockcroft. Registered office:—5, Rawcliffe Street, South Shore, Blackpool.

T. Forknall & Son, Limited.—Capital £2,000 in £1 shares, to take over the business of engineers carried on by T. Forknall & Son at Blake Street, Leicester. Registered office:—4, Grey Friars, Leicester.

Vulcan Steel & Tool Company, Limited. — Capital £10,000 in £1 shares (2,200 preference), to take over the business carried on by N. A. Phaff, at 38, Church Street, Sheffield. First director: N. A. Phaff.

P. & R. Company, Limited.—Capital £1,000 in £1 shares, to carry on business as engineers, etc. First directors: H. H. L. Puxley and A. A. Rogers. Registered office: 15, Wood Street, Wallingford, Berks.

Lancashire Gear Company, Limited. — Capital £7,000 in £1 shares, to acquire the existing business

DIE-CASTING MACHINE AND WHITE METALLING PLANTS

For all Soft Metals, Aluminium Alloys, &c.

CONSISTING OF THE

MONOMETER DIE CASTING MACHINE,
WHITE METAL MELTING FURNACE,
MOULD AND BEARING HEATING OVEN,
——— and TINNING FURNACE.———

We are also Makers of Crucible and Non-Crucible Furnaces in capacities from 30 to 1,000 lbs., and from 1,000 lbs. to 10,000 lbs., for all Ferrous and Non-Ferrous Metals, Steel, Malleable Iron, &c.

Sole Makers:—THE MONOMETER MANUFACTURING CO., Ltd., ASTON, BIRMINGHAM.

The Mastery SIROCCO **of the Air.**

TRADE SIROCCO MARK

FANS

SEND US YOUR ENQUIRIES FOR

are always successful in the struggle for the Mastery of the Air

Ventilation of Ships, Buildings and Mines, Induced Draught on Boilers, Dust Removal, High Pressure Fans for Forge Fires and Cupolas, Air Washers for Cooling and Purifying the Air, Fans for Removing Fumes or Steam, Steam Heater Units for Heating Factories and Workshops.

Davidson & Co., Limited, *Sirocco Works,* **BELFAST.**

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

at Old Trafford, Manchester. First directors: S. Sinclair, A. Tildsley, G. Tomlinson, and J. Woods.

R. A. Evans, Limited.—Capital £10,000 in £1 shares, to carry on the business of lift and hoist makers, etc. First directors:—C. Wells, F. A. Toone, and R. A. Evans. Registered office:—Prospect Road, Leicester.

Bride & Gray, Limited.—Capital £70,000 in 35,000 preference and 35,000 ordinary shares of £1 each, to carry on the business of shipbuilders, engineers, etc Registered office:—156, St. Vincent Street, Glasgow.

G. J. Garrett & Sons, Limited.—Capital £5,000 in £1 shares (2,000 5 per cent. preference), to carry on the business of engineers. Registered office:—Darenth Valley Iron Works, High Street, Sutton-at-Hone, Kent.

Ramsay Condensing Locomotive Company, Limited.—Capital £100,000 in £1 shares. First directors:—J. W. Wood, D. M. Ramsay, and E. A. Mercer. Registered office:—105, St. Vincent Street, Glasgow.

Horwood & Company, Limited.—Capital £10,000 in £1 shares, to take over the business of an engineer, carried on by B. T. Horwood at Hall Street, Dudley, as Horwood & Company. Registered office:—28-9, Hall Street, Dudley.

Light Production Company, Limited. — Capital £10,000 in £1 shares, to carry on the business of ironfounders. First directors: U. V. Roberts and C. E. George. Registered office: 60-66, Rochester Row, Westminster, S.W.

J. & J. W. Longbottom, Limited.—Capital £5,000 in £1 shares, to acquire the business of ironfounders carried on by Messrs. E. L. Firth, C. E. Marsden, and W. Firth, at Bridge Foundry, Holmfirth, as J. & J. W. Longbottom.

Milton, Limited. — Capital £60,000 in £1 shares (10,000 10 per cent. cumulative preference), to carry on the business of engineers, etc. Permanent directors: A. B. Shaw and E. Milton Wildey. Registered office: 24, Coleman Street, E.C.

T. S. Armstrong & Company, Limited.—Capital £12,000 in 5,000 6 per cent. cumulative preference and 7,000 ordinary shares of £1 each, to carry on the business of engineers. Registered office:—4, Worswick Street, Newcastle-on-Tyne.

William Samson & Company, Limited.—Capital £12,000 in 5,000 preference and 7,000 ordinary shares of £1 each, to acquire the existing business of iron, steel, and metal merchants. Registered offices:—88. Great Clyde Street, Glasgow.

Engineer and Builders' Stores, Limited. — Capital £2,000 in £1 and 1s. shares, to acquire the business of the L. F. B. Manufacturing Company and the Engineers' Stores Supply Company. Registered office:—1, Albemarle Street, London, W.

C. H. Butterworth (Bury), Limited.—Capital £5,000 in £1 shares, to take over the business of engineers, etc., carried on at Byron Street, Bury, by C. H. Butterworth. First directors: C. H. Butterworth and F. Butterworth. Registered office: Railway Foundry, Buckley Wells, Bury, Lancs.

T. C. Large & Company, Limited.—Capital £1,000 in £1 shares, to acquire the business of engineers carried on by T. C. Large at 80, Wolsey Avenue, East Ham. First directors: T. C. Large (permanent managing), and F. L. Franklyn. Registered office:—14, St. John's Street, Bedford Row, W.C.

Associated Hardware Manufacturers, Limited. — Capital £150,000 in 5,000 6 per cent. cumulative preference shares of £10 each and 100,000 ordinary shares of £1 each. First directors: F. Hodge, C. F. Gray, F. S. Hodge and D. G. Macintosh. Registered office: 13a, Finsbury Square, E.C.2.

Federated Trading Company, Limited. — Capital £25,000 in £1 shares, to carry on the business of owners of blast furnaces, etc. First directors: F. L. Barber, J. S. Cornwell, L. Rowe, A. E. Percy, R. G. E. Freeman, and C. R. Fitter. Registered office:—Newton Chambers, Cannon Street, Birmingham.

Rennison Walker & Company, Limited.—Capital £10,000 in £1 shares, to take over the business of engineers carried on by W. Rennison and H. B. Kershaw, at Otley Road, Shipley, as William Rennison & Company. First directors: H. B. Kershaw, W. Rennison, and J. E. Walker. Registered office:—Carr Works, Carr Lane, Shipley.

Ernest N. Wright, Limited.—Capital £50,000 in £1 shares, to acquire the business of an engineer and ironfounder carried on by E. N. Wright, at Millfields Foundry, Ettingshall, Wolverhampton. First directors: E. Hickman, E. N. Wright, W. Hutchinson, and C. N. Wright. Registered office: Millfields Foundry, Ettingshall, Wolverhampton.

J. Martin & Sons (London), Limited.—Capital £5,000, to take over the business of engineers and ironfounders carried on at 14-18, College Street, Lambeth, as J Martin & Sons. Permanent directors: Mrs. E. A. H. Martin, M. J. Martin (managing director) and Mrs. E. A. S. Rivers. Registered office: 18, College Street, York Road, Lambeth, S.E.

Allied (Sheffield) Iron & Steel Company, Limited.—Capital £5,000 in £1 shares, to take over the business of an iron, and scrap steel merchant and engineer, carried on by W. G. Laycock, at Sheffield. First directors: W. G. Laycock, 10, Merton Green Road, Sheffield, and F. S. Brightmore, 1, Linden Avenue, Woodseats, Sheffield. Registered office: 18, Cadman Lane, Sheffield.

SANKEY

Pressed Steel Foundry Ladles

Plain or Lipped.

JOSEPH SANKEY & SONS, LD., WELLINGTON SHROPSHIRE.

LEGGE'S IRON CEMENT.

The most efficient for general Engineering and Foundry Work.

It repairs permanently and effectively makes good all defects in Castings, leaking parts and connections in Steam, Water, Gas and Air, etc.

WRITE TO MANUFACTURERS—

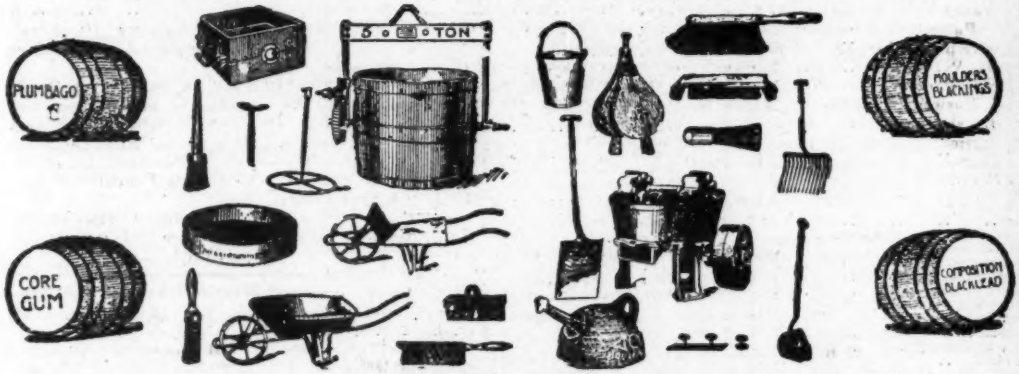
16, South Castle St., F. THOMPSON LEGGE & CO. LIVERPOOL.

Telegrams: "Durrans, Pennistone." Telephone: 21, Pennistone.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



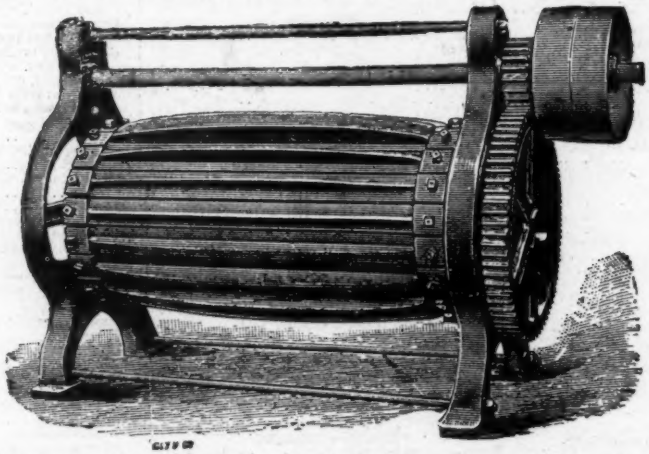
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	Home. £ s. d.
Hematite—	
East Coast Mixed Nos.	9 5 0
East Coast No. 1	9 7 6
West Coast Mixed Nos.	9 5 0
Scottish Mixed Nos.	£9–£9 5s.
Welsh Mixed Nos	9 15 0
Cleveland—	
No. 1	7 19 0
No. 3 foundry G.M.B.	7 15 0
No. 4 foundry	7 15 0
No. 4 forge	7 15 0
Basic	7 15 0
Derbyshire, Leices., and Notts—	
No. 4 forge	7 0 0
No. 3 foundry	7 2 6
No. 2 foundry	7 4 6
No. 1 foundry	7 6 6
Basic	7 7 6
Northamptonshire—	
No. 4 forge	6 12 6
No. 4 foundry	6 15 0
No. 3 foundry	6 15 0
No. 2 foundry	6 17 0
No. 1 foundry	6 19 0
Basic	7 2 6
South Staffordshire, Shropshire and Worcestershire—	
Part-mine forge	7 10 0
Part-mine foundry	7 12 6
Common Staffs.	7 5 0
All-mine forge	8 5 0
All-mine foundry	8 10 0
Warm-air forge	9 15 0
Warm-air foundry	10 5 0
Cold blast	12 10 0
Basic	7 7 6
Scottish—	
Foundry	8 9 0

NOTE.—The above prices are those fixed by the makers as a minimum for May-June delivery. In consequence of works being booked to capacity, makers are now quoting on an average 5s. per ton higher.

Delivered in Manchester—	
*Derbyshire, No. 3	7 15 0
*Cleveland, No. 3	8 2 6
*Scottish, No. 3	9 9 0

* Merchant prices.

Delivered in Sheffield—	
East Coast hematite	9 0 0
Derbyshire basic	8 5 0
Lincolnshire basic	8 3 6
Do. No. 3 foundry	7 10 0
Do. forge	7 7 6

High-Speed Tool Steel.

	s. d.
Finished bars, 14 per cent. Tungsten ..	2 11
Finished bars, 18 per cent. Tungsten ..	3 6

Per lb. delivered buyers' works.

Extras—	
Rounds and squares 3 in. to 8 in. inclusive	4d. per lb.
Rounds and squares under ½ in. to ¼ in.	3d. ,,
Flats under 1 in. by ½ in. to ¼ in. by ¼ in., and all sizes over four times 3 in width and over thickness ..	3d. ,,
Bevels of approved sizes and sections	6d. ,,
If in Coils	3d. ,,
Packing	4s. per cwt
Bars cut to length	10% extra

Scrap from High-Speed Tool Steel—
Scrap pieces, 5d.
Turnings and Swarf, 3d.
Per lb. net, d/d steel-makers' works.

Ferro-Alloys

Ferro-Titanium.—15/18% Ti. and 5/8% car., 8d.
Ferro-Titanium—23/25% Ti. carbonless.
Ferro-Tungsten.—80/90%, 3/6—3/9.
Ferro-Molybdenum.—65/80%, Mo., 14/-.
Ferro-Vanadium.—33/40%, Va., —.
Metallic-Manganese.—90/95% carbonless, —.
(All per lb.).
Ferro-Phosphorus..—20/25%, P.—.
Ferro-Chrome.—4/6%, car., £60 0 0.
Ferro-Chrome.—6/8%, car., —.
Ferro-Chrome.—8/10%, car., —.
Ferro-Chrome,—Specially refined, basis 60% chr., max. 2% car., —.
Ferro-Silicon.—75% Si., £40 0 0
Ferro-Silicon.—45/50% Si., £25 0 0 d/d. at Sheffield Steelworks.
Ferro-Manganese.—80%, £25 loose, £25 15s. packed. Export £30, according to destination.
(All per ton.).

Copper.

	£ s. d.	£ s. d.
Standard cash	78 0 0	78 5 0
Three months	78 5 0	78 10 0
Electrolytic	81 0 0	82 0 0
Tough	80 10 0	81 10 0
Best selected	80 10 9	81 10 0
Sheets	114 0 0	—
India	112 0 0	..
American electrolytic spot	81 0 0	—
Do. May-June ..	81 0 0	—
Do. July-August ..	81 10 0	—
Official average price cash, April	..	77 7 0
Do. Three months, April ..	..	77 5 4½
Do. Settlement, April ..	..	77 8 3
Do. Electro, April ..	..	82 0 3
Do. B.S., April ..	..	81 18 10½
Average spot price, copper, April	..	77 5 3
Do. Electro, April	..	82 1 6

Tin.

	£ s. d.	£ s. d.
Cash	242 0 0	242 5 0
Three months ..	239 0 0	239 5 0
English	235 0 0	—
Bars	237 0 0	238 0 0
Refined	—	—
Straits	238 10 0	—
Australian	..	237 0 0
Eastern	..	—
Banca	..	—
Official average price, cash, April	..	225 6 6
Do. Three months, April ..	..	223 8 4½
Do. Settlement, April ..	..	225 4 9
Average spot price, April	..	225 5 3

Spelter.

	£ s. d.	£ s. d.
Ordinary	36 0 0	—
Remelted	36 0 0	37 0 0
Hard	28 0 0	27 0 0
Electro 99.9 ..	41 0 0	—
English	38 0 0	—
India	35 0 0	36 0 0
Zinc dust	60 0 0	65 0 0
Do. English	70 0 0	—
Zinc ashes, per cent. 70	11 0 0	12 0 0
Official average price, April	..	35 18 3
Average spot price	..	36 2 0

Lead.

Soft foreign (net)	25 0 0
English	25 5 0
Official average price, April	24 8 7½
Average spot price, April ..	24 17 9

Antimony.

English regulus	45 0 0
Chinese	32 0 0
Crude	32 0 0
Ore	Nominal.

Aluminium.

Virgin Metal 98/99—.. .. 150 0 0
per ton.

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II.	—
III., IV., or V.	—
IV. or VII	—
VIII.	—
XI.	—
Cast Strips and Ingots	—
CASTINGS.	Per lb.
I. or II.	—
III., IV. or V.	—
IV. or VII.	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid	—
,, Cored Bars	—

Delivery 2 Cwt. free to any town.
10 per cent. Phosphor Copper .. £40 above price of best selected copper.
15 per cent. Phosphor Copper .. £60 above price B.S.
Phosphor Tin (5 per cent.) .. .. £20 above price of English Ingots.
Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM.

*Chromium (Metallic).

98/99— purity, per lb. — —

*Nickel.

In cubes, 98/99— purity per ton ... —

Nickel Silver.

	per lb.
Ingots for raising	1/4 to 1/9
Ingots for Spoons and Forks ..	1/4 ,, 1/9
,, rolled to spoon size ..	1/6 ,, 1/11

*Tungsten Metal Powder.

per lb.
96/98— purity, per lb. .. .. —

*Molybdenum Metal.

96/98,— purity per lb. .. .. —

*Cobalt Metal.

97— purity, per lb. .. .. .. —

Quicksilver.

75 lb. bottle .. .. —

* Net, delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.	s. d.	s. d.
Steel scrap, heavy melting ..	—	—
Iron scrap cast (cupola metal) ..	—	—
(London f.o.b.).		
Heavy steel	127	6
Light ,, ...	80	0
Heavy cast	120	0

Steel Scrap.	Per ton. £ s. d.
Without Analysis—	
Heavy steel melting scrap	7 0 0
Steel planings, turnings and borings	5 0 0
Steel planings, turnings and borings mixed with wrought-iron or other material	4 5 0
Other classes of steel scrap, whether or not mixed	6 10 0
F.o.r. or in barge at nearest siding or wharf.	
With Analysis—	
Heavy steel melting scrap not over 0.04 per cent. p. and s.	8 0 0
Heavy steel melting scrap not over 0.05 per cent. p. and s.	7 15 0

Wrought-Iron Scrap.

	£ s. d.
(1) (a) W.I. plates and sections, not less than ¾ in. thick, reasonably clear of rivets, flanged ends, etc., suitable for shearing · cable scrap and chain scrap not less than ½ in. dia.	8 7 6
(b) Heavy W.I. scrap not less than ¾ in. thick including horseshoes, rivets and bolts, and scrap therefrom	8 7 6
(c) W.I. scrap under ¾ in. thick, and all W.I. scrap not included in classes 1, 2 and 3	8 7 6
(2) Mixed W.I. scrap	6 17 6
(3) Wrought-iron planings, turnings and borings mixed with steel or other materials	4 12 6
(4) W.I. planings, turnings and borings	5 7 6

Cast-Iron Scrap

	£ s. d.
Heavy ord., broken, between 1½ cwt. and 10 cwt. each	6 17 6
Heavy machinery, broken between 1½ cwt. and 10 cwt. each	7 2 6
Cold blast, broken, between 1½ cwt., and 10 cwt.	8 17 6
Ingot mould, unbroken	8 2 6
Do. broken, between 5 cwt. and 2 tons each	8 7 6
Do. between 1½ cwt. and 5 cwt. each	8 12 6
Railway chairs, whole or broken for remelting	7 2 6
Heavy lumps, not exceeding 2 tons each	6 15 0
Light	6 7 6
Burnt, broken ready for cupola ..	5 12 6
Burnt fire bars	6 2 6
Turnings and borings, for iron and steel makers	5 7 6

Old Metal.

London—	£ s. d.
Copper (clean)	72 0 0
Brass (clean)	48 0 0
Lead (less usual draft)	20 0 0
Tea lead	18 0 0
Zinc	25 0 0
New aluminium cuttings	85 0 0
Brazierv coppper	60 0 0
Gunmetal	72 0 0
Hollow pewter	150 0 0
Shaped black pewter	105 0 0

(Above all d/d merchant's yard).

Metallurgical Coke.

	£ s. d.
Durham and Northumberland—	
Blast furnace	1 19 0
Foundry	2 4 0
Lancs., Staffs., Yorks, Notts., Derbyshire, Lincolnshire and Midland Counties—	
Blast furnace	2 2 0
Foundry	2 16 0

F.o.t. at ovens.

SITUATIONS VACANT AND WANTED.

ASSISTANT MANAGER Wanted, to take entire control of commercial side in young, progressive firm of Ironfounders in Midlands. Must be fully conversant with office work and general organisation, and have practical knowledge of costs and estimates. Good opening for right man. State age, experience and salary to Box 226, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOUNDRY SUPERINTENDENT.—Large Engineering Firm require the services of a First-class Man to take control of their Iron and Brass Foundries and Pattern Shop. Applicants must have held responsible executive positions of a similar character elsewhere, and be capable of handling large range of work up to 50-ton castings.—Applications, which will be treated in confidence, should state age, experience (fully) and salary required to Box No. 220, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

WANTED.—An Energetic Man, to take charge of Iron Foundry capable of an output of 120 tons repetition work per week. Must be expert in Machine Moulding and all modern methods.—Apply, Box 222, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN wanted, with up-to-date experience, for progressive Iron Foundry in Midlands doing jobbing work up to 2 tons. Present capacity (to be increased) 30 tons per week. Must be good organiser and used to handling men. Good prospects for the right man.—Apply, in confidence, stating age, experience and salary required, to Box No. 224, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PRACTICAL FOUNDRY FOREMAN required by Ransomes, Sims & Jefferies, Ltd., Orwell Works, Ipswich, to assist Foundry Manager in large Foundry engaged on repetition work in general and agricultural engineering in the production of Loam and Green Sand Castings in Iron and Brass of medium weight. Age 30 to 35. Must be expert in modern machine moulding and modern methods of quick production, and familiar with the operation of piecework system.—Apply, stating age, full particulars and salary required.

INGOT MOULDS.

FOREMAN WANTED for a works from which a daily output of 200 tons of 3-ton Ingot Moulds is required. A good salary will be paid to a man who has experience of operating jolt rammers, continuous casting, and the most modern methods to ensure the cheapest production. Preference given to a man who has turned out this class of work in greensand, with semi-skilled labour.—Apply, in first instance, giving full particulars of experience, references and remuneration required, to Box No. 200, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

AN Important Company, who are enlarging their Foundry to make large quantities of Aluminium, Steel and Iron Castings, require the services of a HIGH-CLASS FOUNDRYMAN to fix the piecework rates. A progressive staff position to a thoroughly qualified man.—Box No. 216, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

WANTED.—METALLURGICAL CHEMIST, experienced in Iron and Steel Foundry Work. Graduate of Technical College preferred.—Apply, stating fullest particulars of experience and salary required, Box 228, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

SITUATIONS VACANT AND WANTED.—*cont.*

FOREMAN MOULDER for Jamaica required by firm of General Mechanical and Marine Engineers, Iron, Steel and Brass Founders; capable of moulding and instructing others in loam moulding, green sand and dry sand. A married man, and one who has had experience in steel and sugar machinery castings preferred. Salary £6 to £7 per week and quarters, or might pay more for first-rate man.—Write Box "M.948," Lee & Nightingale, Advt. Offices, Liverpool.

AN EXPERT MACHINE MOULDER and Pattern Plate Moulder would like a position of trust with a Firm where abilities would be appreciated. The advertiser is practical, and would prove to be a first-class man to a Firm who are introducing Moulding Machinery.—Address, Box 230, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN MOULDER wanted for Sheffield District, used to Electric Steel for Motor work preferred. State age, wage and experience.—Address, Box 232, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

WANTED, for steel foundry near London, thoroughly experienced PATTERN MAKER for new pattern shop. Man engaged must be experienced in pattern making and pattern plate making for machine moulding.—Write fully, stating experience and wages required, and enclosing copies of testimonials to Box 202, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOR SALE AND WANTED.

FOR SALE.—Two No. A5, one No. A3, and one No. R3 Bonvillain Universal Hydraulic Moulding Machines.—John Jardine, Ltd., Nottingham.

FOR SALE.—Small Iron and Brass Foundry and Engineering Works, about 30 miles from London, on Main Line. Good orders on hand. Or would consider an experienced working partner.—Box 218, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOR SALE.—New crucibles, by Morgan Crucible Co. 1,200-200 lb. crucibles, 230-60 lb. crucibles. Offers invited. F.O.R. Braintree.—Apply, The Cuttall Manufacturing Co., Ltd., Manor Works, Braintree.

MISCELLANEOUS.

ENGINEERS, Architects and Builders experienced in the designing and erection of modern labour-saving shops for general engineers are invited to submit their proposals and references of work done, and if favourably considered the applicant may anticipate hearing further from the advertiser.—Box No. 208, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FIRM of General Engineers contemplate the erection of a Modern Labour-Saving Casting Foundry to employ 250 moulders and casters. They invite designers, builders and patentees to submit suggestions, plans or appliances for consideration with a view to adoption if suitable. Suggestions invited to utilise the waste heat of the cupolas for raising steam for heating and other purposes at low pressures.—Write, Box No. 206, FOUNDRY TRADE JOURNAL, 165, Strand, London. W.C.2.

Established 1890. Telegrams: Wm. Olsen, Hull.

CORE GUM. — **GLUTRIN.** — CORE OIL.

PARTING. — PLUMBAGO.

WAX CORE VENTS.

CRUCIBLES. — **RESIN.** — GANISTER.

Motto—'The Right Articles at the Right Price.

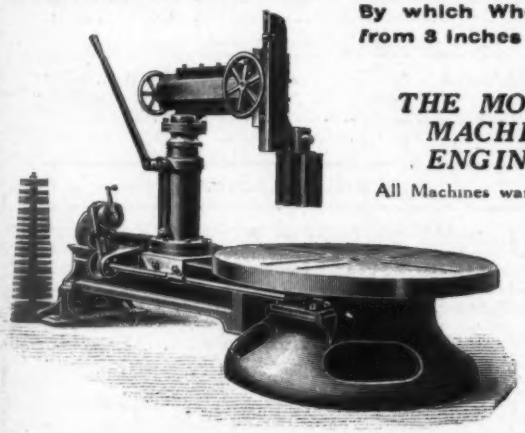
WILLIAM OLSEN, Ltd.,

Materials and Requisites for Ironwork, Brassfounders, &c.,

COGAN STREET, HULL.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



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